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BY

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RESEARCH IN MEDICINE

The Hitchcock Lectures at the University of California*

By Richard M. Pearce, M.D.,

Professor of Research Medicine, University of Pennsylvania

LECTURE I

Antiquity to 1800; The Efforts of Isolated Investigators

The phrase "Research in Medicine" will naturally arouse different thoughts and associations in the minds of different groups of men. The bacteriologist will be reminded of Pasteur, Koch, Behring and Flexner and the triumphs of bacteriology and serum-therapy; the surgeon, of Lister and antisepsis, of anesthesia, and of the X-ray; the physician of new means of cure and of diagnosis, of specific sera and vaccines, of the electrocardiograph, the polygraph and other complicated instruments of precision; and the average layman of a confused and confusing welter of catchwords and slogans for popular agitations vaguely associated with antitoxins, mosquitoes, good water supply, sewage disposal, lowered infant mortality and the modern treatment of tuberculosis. But in the last analysis the impressions of all would be of progress in a period representing a little more than half of the past century. This period is indeed the golden age of medical progress and one to which the historian or philosopher must give his best attention if he is to interpret properly the impulses which actuate medical research at the present time. That the earlier history of medicine is overshadowed by the rapid progress of modern discovery as represented in

* A course of five lectures given January 23 to 26, 1912, and printed in *The Popular Science Monthly*, May to September, 1912. The Hitchcock Lectures were established by Mr. Charles M. Hitchcock, who bequeathed to the University of California an endowment, the income of which was to be devoted to "free lectures upon scientific and practical subjects, but not for the advantage of any religious sect nor upon political subjects."

bacteriology is in the nature of things. But it should not, for that reason, be forgotten that the art of medicine existed before this period and with it much science. The pathologist, on second thought, reminds us of Morgagni and Rokitansky and the beginnings of pathological anatomy; the physiologist recalls Harvey and Haller; the surgeon mentions Ambroise Paré; the anatomist, after recalling many worthies, takes us back to Vesalius, to Galen and finally leaves us as does the internist, with Hippocrates, 400 years before Christ.

With this stretch of time and with these widely varying aspects of endeavor one must deal in attempting to present the story of research in medicine. It would be comparatively simple to chronicle the advance in any one field, as, for example, surgery, pathology or therapy; but this would, I fear, be less interesting and certainly not enlightening as to the full influence of research. The advantages to the community resulting from research in medicine are advantages because research has done away with conditions which were disadvantageous to the health, the happiness and prosperity of the community—in short such research has removed the impediments to a higher, happier and more prosperous civilization. It is necessary, therefore, in order to emphasize the importance of what has been accomplished, to portray the conditions of community life and individual hygiene, of medical practise and medical thought, and of science and philosophy at such periods as immediately precede definite advances in medical knowledge. The first of these lectures, then, bringing the story down to the beginning of the nineteenth century, will be presented from this point of view. The second lecture devoted to the influence of physics and chemistry, and the third to the rise of bacteriology, will outline the development of laboratory methods of investigation, the story, essentially, of medicine in the last half of the nineteenth century. The fourth lecture will be a survey of present-day methods and problems, and the fifth lecture will be a discussion of the position of medical research in America, its facilities, needs and opportunities, with special reference to medical research as a function of the university.

Of medicine in the earliest stages of its development we have no knowledge. Not until we arrive at a period of civilization as highly developed as that of the Assyrians and Egyptians do we find references to the practise—the studied practise—of medicine as a healing art. For all that precedes that period we must rely on analogy with med-

ical practises among the aboriginal races to-day. But we can, nevertheless, safely assume that the healing art in all times, no matter how simple its form, was the practise of methods having for their object the relief of pain or the repair of injuries caused by mechanical means. Such methods must have been, at first, instinctive and empiric, or the result of chance observation. Some may, indeed, have been analogous to the methods which an animal adopts to cleanse a wound or protect an injured limb. The use of irritants, of emollients and of scarification, the binding of wounds, the mechanical support of a fracture and assistance in childbirth are primitive practises doubtless resulting from chance observation or experience. It is readily conceivable that the use of stone tools and weapons in hunting and in war may have originated the idea of intervention by operation; and that surgical dexterity may have increased proportionately to the improvement of weapons in the bronze age. Likewise it must be assumed that chance experience led to a knowledge of the action of the vegetable and mineral substances of the early materia medica. But of these beginnings we have no historical knowledge.

Our first authentic knowledge of medicine, fragmentary though it is, is obtained from the cuneiform inscriptions which record the Babylonic-Assyrian civilization. These records are of a medicine controlled by the priesthood, closely linked to astrology and characterized by a belief in the influence of metaphysical forces, gods and demons. They do, however, contain references to the use of the knife in surgery, the healing of fractures and the internal administration of herbs, but all essential therapy is obscured by mysticism, ritual observances and magical formula. From the point of view of diagnosis, it is of interest that these records refer to the inspection of the urine and blood and to the collection of a series of observations upon disease, what we would now call the "clinical history" or record of a patient. These, however, were taken, not as to-day to aid in the diagnosis, but had the value of omens to aid the priest in his prophecy as to the outcome of the illness, or as we would say to aid prognosis. Such records were of little value, for without a knowledge of pathology—that is, of the underlying anatomical changes responsible for the symptoms—they were on the same level as astrological speculation and the interpretation of dreams. Inferences were not drawn from the empirical facts of clinical observations, but all observations were interpreted in the light of the super-

natural, the ritualistic and the magical. This veil we find over all ancient medicine.

Egyptian medicine of a period 2,000 B.C. was much the same as the Assyrian, but the priestly science, as taught in the schools of the temples, developed a considerable knowledge of botany and zoology, without, however, an insight into the structure and functions of the human body. An extensive materia medica allowed the use of medicines as draughts, electuaries, gargles, snuffs, inhalations, salves, plasters, poultices, injections, suppositories, enemata and fumigations. As to general surgery, there is no evidence, aside from circumcision and castration, of operations other than those for the removal of surface tumors. Yet ophthalmology, otology and dentistry were known and practised as specialties. Obstetrics, on the other hand, does not appear to have been of interest to the physician. The hygiene of the Egyptians ranked higher than their therapeutics and included definite rules concerning meat inspection, bathing, clothing, diet, care of the dwelling and of infants. Indeed there is much ground for the belief that much of our modern hygiene can be traced back through Greek and Hebrew to the pioneer work of the ancient Egyptians.

Persian medicine is of little moment and differs but slightly from that of other ancient peoples in its religious-hygienic measures. One phase of religious belief was disastrous for the development of even simple empiricism—the belief that the dead and the diseased were unclean. Such a view naturally made impossible the study of anatomy and diagnosis. The sick, as unclean, were isolated, washed and purified —a procedure which in our time we associate with good hygiene and the care of those suffering with contagious diseases; with the Persians, however, it was purely a religious form based on a belief in demons.

After the priestly hygiene of the Egyptians and Persians comes naturally, and probably sequentially, the social hygiene of the Old Testament. I need only remind you of the Mosaic laws, rational even in the light of modern science.

From the literature of antiquity much else might be cited to show the state of medicine among ancient peoples, the influence of religion, of primitive superstition and mysticism, all of which, however well-intentioned, prevented or obscured exact observation and deduction. The development of knowledge by observation and critical argument came slowly, and was possible only when the priest was no longer the

physician. This great advance we associate with the period of Greek civilization and the name of Hippocrates.

Hippocrates may be considered in many ways, as physician, surgeon, philosopher and medical historian, but to one interested in the beginnings of research in medicine he is of importance as the first to record results based on observation, experiment and deduction, the tripod of the method of science. As a result, although much of his theory has been discarded, many of his procedures based on exact observation still stand the test of time and in many instances form the basis of modern methods. His age (470–361 B.C.) was the age of Pericles; contemporary with him, Thucydides wrote history, Phidias carved statues, Democritus originated his atomistic theory of the universe, and Socrates talked "human affairs" and "practical reason." That these men were real to one another is shown by the fact that Hippocrates was requested to declare Democritus insane and that Pericles died (429 B.C.) of the great plague which Hippocrates attempted to combat.

From this correlation of names it is evident that medicine shared in the general growth of Greek culture, and there is every evidence that Hippocrates was as great a representative of Greek intellect as were his contemporaries. Greece was at the height of its brilliant progress; it was, for the time being, the political, commercial, intellectual, scientific and artistic center of the universe. But among the Greeks the priests were not, fortunately for medicine, political or intellectual leaders; leadership was possessed first by the poets and later by the philosophers, and, under such circumstances, Greek medicine, freed of religious influence and fostered by philosophy, took a substantial form, and, though it contained much of generalized speculation, it had the solid foundation of unbiased observation. The former has perished under the influence of time and progress; the latter, resting on actual experience and genuine biological knowledge, remains. Of the methods of Hippocrates some idea may be obtained from the fact that he is responsible for the very term "hypothesis," which, in its scientific application, he invented.

Some of the experiments of the Hippocratic schools may be considered as the first in the field of experimental physiology, as for example, the feeding at the same time of different kinds of food and the study, after induced vomiting, of the stage of digestion of each. It is, however, in the field of clinical observation that Hippocrates

excelled. His inferences were frequently wrong, but his descriptions of the symptoms of a disease, as an aid to diagnosis and prognosis, were at once picturesque and accurate. How accurate and vivid they were may be seen from the fact that the characteristic signs of impending death are still known as the "facies Hippocrates." This exercise of minute observation and accurate interpretation of every symptom—the method of clinical medicine—which has influenced medicine in all succeeding ages, was the beginning of the study of what we now term the "natural history of disease." In therapy Hippocrates recognized the natural tendency to health (*vis medicatrix naturæ*) and this principle influenced all his therapeutic efforts. In addition to this substantial service to medicine we owe him certain idealistic influences as shown in the Hippocratic oath and in his constant desire to place all knowledge freely and fully before the profession at large.

Certainly medicine under Hippocrates, as contrasted with that of the preceding ages, was magnificent, and it is not surprising that after his death, he was deified. To us he represents the beginnings of an exact medicine, and his influence is seen in many of the theories, methods and ideals of modern practise. Hippocratic medicine, Hippocratic doctrine, Hippocratic oath, are current phrases, and the admonition "Back to Hippocrates" is an admonition to beware of theory and seek the solid ground of observation and experiment.

Between Hippocrates and Galen lie nearly five hundred years without progress in medicine, except as the brilliant Alexandrian school, sheltering Euclid, Archimedes and Ptolemy developed, under Herophilus and Erasistratus, a school of anatomy (ca. 300 B.C.) which established many new anatomical facts. But as Neuburger states in his discussion of early medical theories, "Collection and observation of facts constitute the first step in science, but not science itself." The observation of anatomical facts during these centuries is naturally of some importance in connection with the growth of anatomy, but unfortunately of no importance as regards the influence of those facts on medical theory, for physiology remained a field for speculation while the facts gained from anatomy were used only to strengthen the older speculation and dogmatism, and to rehabilitate discarded doctrines. To the Alexandrian school and to Galen, however, must be given the credit of a careful study of anatomy by dissection, and this honor is the more deserved because, from Galen to Vesalius—a stretch of nearly fourteen hundred years—knowledge of anatomy was not advanced.

Galen (131–201 A.D.), a Greek, working in Rome, followed the traditions of the Alexandrian school in which he had been educated. He dissected freely a variety of animals, including, it is recorded, an elephant. It is, however, as an experimental physiologist that he brought new light to medicine. He supported the statements of the Alexandrian school, that nerves had motor and sensory functions, elaborated the theory of the control of muscles by nerves, and of the brain as the center of the nervous system, and, more important still, supported these convictions by well-planned ingenious experiments. His experiments on the brain and cord constitute the first experimental study of the cause of paralysis, and he thereby became cognizant of the fact that injury to one side of the brain affects the opposite side of the body. He established, again by experiment, that urine is secreted by the kidneys, and propounded the theory that the blood goes to the kidneys in order that the watery part may be filtered off. He studied the heart and its movements, recognized the fetal nature of the foramen ovale and the ductus arteriosus, wrote of aneurism and practised the ligation of arteries.

Galen is the link between Hippocrates and Alexandrian anatomy, on the one hand, and Vesalius and Harvey, on the other.

With his death and the passing of his immediate successors progress languished and expired, for the ancient world was dying and was bearing down with it the humaner arts. . . . For generations it seemed that the church alone had survived . . . cherishing ignorantly often, but jealously and fiercely, the records of a past science. (Mumford.)

The intellectual world of Rome, Alexandria and Constantinople was busied with theological controversies. The church became the arbiter of all knowledge and demanded that all science must conform to the Scriptures. Moral and intellectual progress became impossible. The political world survived the invasion of the barbarians, but the intellectual world was dying of dogma. For hundreds of years it was "first the soldier; second the priest; third the lawyer; fourth the merchant; fifth the physician; and then after a long interval the surgeon, ranking with the humblest of craftsmen." (Mumford.)

Nearly fourteen centuries pass after Galen before we can again take up the thread of progress. In these centuries—lost to science generally—the history of medicine shows but one isolated period of effort worthy of mention. This is that period represented by the Arabian school founded after the Mahommedan conquest and at its best from

the ninth to twelfth centuries. This school represents no progress in anatomy, physiology or the general theory of medicine (which is to be explained by the fact that the religion of the Mussulman considers contact with a corpse sacrilege and thus debars dissection), but the Arabs had an insight into chemistry, and, though they pursued their researches in the interests of alchemy and in the hope of finding the "elixir of life" or means of transmuting metals, they made, nevertheless, valuable chemical discoveries and in this way aided the art of pharmacy.

We therefore enter the sixteenth century of the christian era with little or nothing added during 2,000 years to Hippocrates's methods of exact observation in clinical medicine and surgery, with no decisive contribution to anatomy or experimental physiology for 1,300 years and with the beginnings of chemistry as applied to medicine and pharmacy removed by 600 years.

But despite this absence of real progress, a thin thread of learning and practise connected the medicine of Galen with the dawn of science in the middle ages. This is evident in the story of medicine in the monasteries and in the schools at Salerno and Montpellier in the twelfth century, but it is a medicine of the Roman period tinctured with magic and superstition and with no advance in theory or practise and certainly no increase in science.

The medicine associated with the revival of learning had its beginnings in the translation of Greek treatises on medicine through the Arabic; and in the early universities, especially those of Padua and Bologna and this revival of the exact methods of Hippocrates and Galen, gave to medicine a basis more substantial than the traditions of monastic medicine which had been perpetuated through ten centuries, and upon which were founded those widely scattered, but epoch-making advances which medicine reckons as its share in the general revival of literature, art and the sciences. With the name of Luther, Michael Angelo, Raphael, Titian, Copernicus, Columbus and Galileo we place those of Vesalius, Paré and Harvey. These names represent the period of the Renaissance, to which we look back with pride and satisfaction, but seldom with a thought of the conditions of home and community life. We are concerned usually with its deeds and achievements rather than with its social and hygiene conditions. But it is to the latter that I wish here briefly to direct attention.

The homes and habits of the people were filthy. As late as the sixteenth century in England, the streets of the populous cities were paved with straw and rushes, which soon broke up into powdered dust. Householders swept the filth of their apartments into the streets, and threw garbage there also, where, with the ground of rush and straw, a most intolerably filthy condition was produced, which rain modified, but did not remove. Moreover, people seldom bathed their bodies or washed their clothes. Besides, the food they ate contributed to disease. They lived chiefly on salt fish and flesh, with a modicum of stale vegetables. The domestic animals, the source of their meat, were herded in enclosures of the worst imaginable filth. Mutton was the chief flesh food of the people, but their flocks in cold season were herded in basements, partly underground, places without light and air except such as gained admittance from the door. Milch cows were confined to these places also. The source of the food supply was, therefore, foul. . . . Places of public resort were without means of ventilation. The air of the churches was death-dealing, and made tolerable only by the fumes of incense. (Gorton.) Personal cleanliness was unknown; great officers of state, even dignitaries as high as the Archbishop of Canterbury, swarmed with vermin; such it is related was the condition of Thomas a' Becket, the antagonist of an English king. To conceal personal impurity, perfumes were necessarily and profusely used. The citizen clothed himself in leather, a garment, which, with its ever-accumulating impurity, might last for many years. . . . After night-fall the chamber shutters were thrown open, and slops unceremoniously emptied down. (Draper.)[1]

[1] The original upon which these statements are based I have been unable to obtain. Gorton's statement is evidently at second hand. C. Creighton in his "History of Epidemics in Great Britain" doubts the accuracy of the sweeping charges "of neglect of public hygiene" and "of lack of rudimentary instincts of cleanliness" in Plantagenet and Tudor times, but as careful a writer as F. Harrison gives in "The Meaning of History" the following summary of personal and community hygiene in the Middle Ages:

"The old Greek and Roman religion of external cleanness was turned into a sin. The outward and visible sign of sanctity now was to be unclean. No one was clean; but the devout Christian was unutterably foul. The tone of the Middle Ages in the matter of dirt was a form of mental disease. Cooped up in castles and walled cities, with narrow courts and sunless alleys, they would pass day and night in the same clothes, within the same airless, gloomy, windowless and pestiferous chambers; they would go to bed without night clothes, and sleep under uncleansed sheep-skins and frieze rugs; they would wear the same leather, fur and woolen garments for a lifetime, and even for successive generations; they ate their meals without forks, and covered up the orts with rushes; they flung their refuse out of the window into the street or piled it up in the back-yard; the streets were narrow, unpaved, crooked lanes through which, under the very palace turrets, men and beasts tramped knee-deep in noisome mire. This was at intervals varied with fetid rivulets and open cesspools; every church was crammed with rotting corpses and surrounded with graveyards, sodden with cadaveric liquids, and strewn with disinterred bones. Round these charnel houses and pestiferous churches were piled old decaying wooden houses, their sole air being these deadly exhalations, and their sole water supply being these polluted streams or wells dug in this reeking soil. Even in the palaces and castles of the rich the

From the fourteenth to the sixteenth century plagues were frequent and attended with great mortality. Among the plagues known by various names as the "sweating sickness," "black death," etc., we are able to distinguish bubonic plague, typhus and small-pox. Likewise syphilis had been on the increase since the fifteenth century, and presented a peculiar malignancy, and, like small-pox, attacked high and low alike. The causes and origin of these plagues are not difficult to find. Except for the Cloaca Maxima at Rome not a sewer of any consequence existed in Europe; drainage was inadequate, the streets were unpaved, and public baths or other facilities for bathing were unknown. Of sanitation no knowledge was at hand. The dead, including the victims of various plagues, were buried hastily—instead of being burned —and usually in shallow ditches, thus allowing presumably an easy pollution of water supplies. As to this, under ordinary circumstances no precautions were taken to keep the water supplies free from fecal and other contaminations. Doubtless, taxes on bread and window panes were responsible in no small part for that diminished resistance which invites infection. Against the spread of plagues the physicians were helpless. The College of Physicians at Paris in the fifteenth century at the time of the "sweating plague," were, after mature consideration, "of the opinion, that the constellations, with the aid of nature, strive, by virtue of their divine might, to protect and heal the human race." This state of mind does not seem so surprising when we recall that Roger Bacon, "the truest philosopher of the Middle Ages," still sought, in the thirteenth century, the philosopher's stone and the elixir of life. "The Royal Touch" was still a favorite cure for scrofula ("The Kings of Evil") and various other ills, and indeed persisted into the time of Queen Elizabeth. From "The Anatomy of Melancholy" (1621) we have it that "there be many mountebanks, quacksalves and empiricks, in every street almost, and in every village."

same bestial habits prevailed. Prisoners rotted in noisome dungeons under the banqueting hall; corpses were buried under the floor of the private chapel; scores of soldiers and attendants slept in gangs for months together in the same hall or guard-room where they ate and drank, played and fought. It is one of those problems which still remain for historians to solve—how the race ever survived the insanitary conditions of the Middle Ages, and still more how it was ever continued—what was the normal death-rate and the normal birth-rate of cities? The towns were no doubt maintained by immigration, and the rural labourer had the best chance of life, if he could manage to escape death by violence or famine."

Shall we, then, wonder that, in the famine of 1030, human flesh was cooked and sold; or that, in that of 1258, fifteen thousand persons died of hunger in London? Shall we wonder that, in some of the invasions of the plague, the deaths were so frightfully numerous that the living could hardly bury the dead? By that of 1348, which came from the east along the lines of commercial travel and spread all over Europe, one third of the population of France was destroyed. (Draper.)

Also, the condition of the insane was pitiable; until well into the eighteenth century they were imprisoned, chained and treated as wild beasts.

Rational therapy did not exist, though it is interesting to note that several important empiric specifics came gradually into general use, as mercury and sulphur introduced in 1510 by Paracelsus, sometimes termed "charlatan and bombast"; after Harvey's time, Dover's powder (*Pulvis Ipecacuanhæ* Comp.) through Captain Dover, physician and buccaneer; and *Cinchona* (quinine) through the Countess of Cinchon, wife of the Viceroy of Peru, who brought it to the attention (1638) of the Jesuit priests, hence the name, Jesuit's bark. Truly, empirical therapy made progress by curious routes.

Civil surgery was in a chaotic state, the barber surgeon contended with the surgeon proper or "surgeon of the long robe" in the fields of minor surgery and both ranked far below the physician. In fact, surgery was largely abandoned to a class of ignorant barbers, bathers and bone-setters. Many operators were itinerant, going from city to city and frequently limiting their work to one or two kinds of operation, as that for cataract, or stone, or hernia. Military surgery without anesthesia or antisepsis was a horror of rough and ready emergency operations with boiling oil or heated iron as styptic and cautery, a torture beyond imagination. Indeed, to get an idea of the horrors of surgery in the lazaretto of the battle field even down to the year 1812, the date of Napoleon's descent upon Moscow, one needs but to read Tolstoy's work "War and Peace."

Thus we find the stage set for Vesalius and Paré, who with Hunter, though he entered somewhat later, laid the foundation, which, when anesthesia and antisepsis were added in the nineteenth century, gave surgery its right to claim a scientific basis. Vesalius, occupying a chair of surgery at Padua, developed anatomy as an exact observational science; indeed he may be considered as the founder of modern anatomical research. This was his great work; this and his influence in weakening

the old speculative medicine and in establishing the principles of the scientific method. It was not an immediate influence, for upon the publication (1543) of his Fabrica Humani Corporis "the wrath of intrenched conservatism descended upon him" and he was forced to leave Padua, but his work was not in vain, for it hastened the development of surgical science and gave to anatomy the impetus necessary for its development as an observational science.

Ambroise Paré (1510–1590) began life as an humble barber-surgeon, and ended as the greatest surgical authority of Europe and the best loved man in France. (Mumford.)

Why the greatest authority? Because he went through the world with his eyes open. Why the best beloved? Because of his own unaided efforts he did away with more actual pain than has perhaps any other single individual except the discoverer of anesthesia. His methods were those of the practical clinician—observation as the basis of deduction unhampered by tradition. The story is told that Paré in his first military campaign followed the old custom which prescribed the use of boiling oil for all wounds. But after one severe engagement the oil gave out and he used, fearful of the consequences, a simple ointment. To his surprise he found that the wounds so treated healed more rapidly than under the old treatment. On this basis of simple observation and sound reasoning, he combated, against great opposition, the old treatment and established simple rules for the care of wounds. So also was it with the ligation of vessels after amputation. The custom had been to cauterize with the red-hot iron, the effect of which both physically and mentally it is not difficult to imagine. Paré reasoned that as ligation of veins and arteries in simple wounds was possible, it was possible also at amputation, and at the first opportunity he demonstrated the correctness of his views. So by doing away with boiling oil and the heated iron he ranks among the greatest of humanitarians and, by establishing rational procedures for the treatment of wounds and for the ligation of vessels, as one of the greatest of surgeons.

Here it is well to depart from the chronological order and discuss John Hunter and his work and thus bring the advance in surgery to the year 1800. Between Paré and Hunter surgery was influenced by Haller and Harvey, but both these must be treated in detail in a consideration of other lines of activity. Suffice it to point out here that Harvey's work on the circulation of the blood and Malpighi's discovery

of capillary circulation advanced surgery enormously by clearing up for the surgeon the mysteries of the blood-vascular system. The dread of hemorrhage had previously deterred surgeons from all operations except those of dire necessity or those in which the operation was in a gangrenous tissue. With this mystery of hemorrhage solved, the surgeon boldly ventured into new territory and rapidly extended the possibilities of his art.

John Hunter, pathologist, physiologist and surgeon, was active in the latter part of the eighteenth century. He worked in anatomy, comparative anatomy, physiology and surgery; essentially a laboratory investigator, "content" it is said "with four hours of sleep, scanty rations and little play." (Mumford.) Many were his contributions to anatomy, but his work on coagulation of the blood, inflammation and the repair of wounds, and, above all, the demonstration, that after ligation of vessels there occurs the establishment of a collateral circulation by anastomosis, were of the utmost importance to surgery. This latter, the basis of his famous operation for aneurism, was the result of a study of the growth of deer's antlers, in the course of which he tied one of the carotid arteries. To his surprise the cold antler of the ligated side, after two weeks, became warm. Dissection demonstrated that the ligature had not slipped, and on the basis of this observation he established those principles concerning the ligation of vessels in continuity so important in modern surgery. He also presented the first satisfactory explanation of inflammatory and thrombotic diseases of veins and contributed to the knowledge of gunshot wounds and of many other phases of medical science; but his great influence was the impetus which he gave to proper scientific research in medicine as well as surgery, in pathology as well as physiology.

To Hunter, the nineteenth century English school of surgery owes its fame, and in his honor the Royal College of Surgeons established the annual Hunterian Oration. After Hunter, and largely due to his influence, surgery advanced surely, though slowly, but without momentous discoveries until the advent of anesthesia and asepsis in the middle of the nineteenth century. We may therefore leave surgery and turn to Harvey and events in physiology prior to 1800.

Harvey was of the Elizabethan period, a contemporary of Shakespeare, Milton, Dryden, Bacon, Descartes and Kepler. He studied at Cambridge and Padua and on his return to England, as Lumleian

lecturer, gave most of his time to teaching and dissection. It was during the second year (1616) of such labors that he first propounded his theory of the circulation of the blood, but it was not until 1628 that his complete work on the subject was published. With the discussion as to the part played by his forerunners, by Servetus, Cæsalpinum and others in elucidating the mysteries of the circulation we are not now concerned. The honor of the establishment of the theory is Harvey's. More than this, it was the character of his exhaustive observations on a score of different animals (and on the heart of the chicken *in ovo*), his logical reasoning, and his convincing experiments that finally led to the correct solution and to the resurrection of a new method in medicine, that of experimental physiology. It may be remembered that Galen has been referred to as the first experimental physiologist; after fourteen hundred years he was followed by Harvey; then came Haller and Hunter, prophets of that modern experimental physiology which was in the nineteenth century to advance along all lines and to give to medicine a scientific foundation.

It is difficult to overestimate the significance of Harvey's discovery of the circulation of the blood. Sir Thomas Brown considered it greater than Columbus's discovery of America; Hunter ranked it with that of Columbus and that of Copernicus. Certainly it opened a new world in medicine. Progress, however, did not immediately follow Harvey's discovery, though four years after his death the capillary system, a link necessary to the completion of his doctrine of the circulation, was discovered by Malpighi. The period, was, however, one of detailed observation in anatomy, and despite the work of Malpighi and Borelli, experimental physiology languished until the time of Haller (1708–1777), who made additions to the knowledge of the mechanics of respiration, established the theory of irritability as a specific property of muscle and made important observations in embryology. How prophetic of the advances of the nineteenth century are the problems with which Haller and Hunter busied themselves. The study of the irritability of muscle suggests physiological instruments of precision, and embryology implies the compound microscope and the microtome, the familiar instruments of the latter nineteenth-century investigator [illegible] medicine. Hunter's problems—phlebitis, aneurism, syphilis, inflam[illegible]tion, the repair of wounds, the coagulation of the blood—remind [illegible] of many phases of present-day investigation. Prophetic also of the

phenomenal development of pathology, under Rokitansky and Virchow, was Morgagni's publication in 1761 of his "Seats and Causes of Disease," the first systematic effort to correlate clinical manifestations with pathological anatomy. Likewise, the introduction by Jenner (1796) of the systematic practise of vaccination against small-pox, presaged those methods of prophylaxis which within the next century were to revolutionize the methods of controlling many of the infectious diseases. We will return in later lectures to both Morgagni and Jenner and their influence on the development of pathology and immunology, but here they serve with Hunter and Haller to illustrate how a few individuals with a genius for accurate observation, sound thinking and exact experimentation may by their contributions foreshadow the activities of a succeeding century, and be the forerunners of new schools of thought. Their labors with those of Vesalius, Paré and Harvey are examples of that effort which, isolated though it was, during the three or four centuries preceding the year 1800 and proceeding as it did from individuals living and working in widely separated places, nevertheless, constituted in the sum a sound body of knowledge readily available to future investigators, equipped with new methods. With the exception of Paré no one of these men was thoroughly appreciated by his contemporaries. Vesalius was reviled and forced to leave Padua, Hunter's ligation of a vessel in continuity was at first ridiculed and Harvey's discovery, like others in various fields, because not possible at once of practical application, did not appeal to medical men who still clung to the traditional teachings of Galen. It was the period of genius working alone without the approval of the profession, without the support of universities and laboratories, and without the means of publications and the means of travel that to-day render almost immediately available new advances, achievements and theories. One had to journey to the city or country of this or that authority or investigator to get his views. Merz, in his "History of European Thought in the Nineteenth Century," gives, as examples of such voyages of discovery Voltaire's visit "to England in 1728, where he found the philosophy of Newton and Locke, at that time not known and therefore not properly appreciated in France; the journey of Adam Smith in 1765 to France, where he became acquainted with the economic system of Quesnay"; and the visit of "Wordsworth and Coleridge to Germany, whence the latter brought to England the new philosophy of Kant and Schelling." It is

not surprising that under such circumstances advances in medicine, as in science generally, were few and far between.

How the change from individual to organized effort came about, and how medicine became the subject of investigation by scientific methods in laboratories established for that purpose will be shown in the next lecture.

LECTURE II

The Development of Laboratories for the Medical Sciences

It would be interesting to trace in the events and activities of the later years of the eighteenth and early years of the nineteenth centuries that development of general thought which exerted indirectly an influence on modern medicine; but, under the circumstances, I can outline only a few; it was the period of the struggle for American Independence, of the French Revolution and of England's abolition of the slave trade. The world was becoming wiser and more humane; men and women were no longer hanged for witchcraft; the principle of education for all was being recognized; and it was also at this time that the insane were treated as persons ill of disease and not as prisoners, to be chained together and crowded into filthy pens until death should end their misery.

Captain Cook was enlarging the boundaries of the known world, Daguerre was establishing the art of photography, Murdoch was developing the use of coal gas as an illuminant, Watts was improving the steam engine, Fulton was concerned with the steamboat and Stephenson somewhat later with the steam locomotive. Machinery was being invented to replace hand labor, and advances in technical and industrial procedures were rapidly following one another.

It was likewise a period marked by the rise of great chemists and physicists, as Lavoisier, Scheele, Priestley, Avogadro, Dalton, Gay-Lussac, Davy, Volta, Franklin and Galvani; great naturalists as Cuvier, Humboldt and Lamarck; and great astronomers and mathematicians as Herschel and Laplace. At the time, the activities of these men were not seen to be directly contributory to the science and practise of medicine, but as the years went on and it became more and more evident—largely as the result of their work—that knowledge was to be gained

not by establishing all-embracing systems of philosophy, but by the accumulation of facts through exact observation and experiment, their methods became the property of all branches of science and so, naturally, of medicine. In addition to method, moreover, these men offered, in the fruits of their labors, a not inconsiderable amount of data of direct value to medicine, in the establishing of sound principles of physiology.

In the meantime, however, the practise of medicine labored under great difficulties and was largely a matter of empiricism. Without a knowledge of etiology, without pathological anatomy, that firm foundation for diagnosis, and without a rational therapy it could be nothing else. Mercury, cinchona, cathartics and bleeding were the general methods of treatment. Great and noble men filled the universities and hospitals; they labored conscientiously, and elaborated systems, and did what they could to relieve human misery, but to the advance of the science of medicine they contributed little or nothing.

Anatomy as a descriptive science dealing with adult structures and their gross appearance had been well established; but it waited for its fullest development upon the methods destined to establish histology and embryology. Experimental physiology, except as Haller and Hunter had influenced it, was an unknown field, soon, however, to be widely explored as the result of the introduction of instruments of precision and analytical methods. Pathology, dependent upon the methods of histology and physiology was marking time, and, in turn, internal medicine awaited the development of pathological anatomy. Surgery, slowly improving technical procedures, likewise marked time until anesthesia and asepsis opened new worlds to it.

The advance in these general subjects it is my intention to follow along the lines of physics, chemistry and biology, as they developed in France, England and Germany. And, if in the course of this presentation I have much to say about the work shops of these sciences, it is because universities, laboratories and hospitals, as well as societies and journals, represent the visible machinery of nineteenth century research in medicine, and whether we regard them as the cause or the effect of the awakening of 70 years ago, they to-day constitute our hope for the future of medical research.

It is difficult to select a starting point for a systematic survey. Chemistry, however, appears to promise the most direct course, for it

was toward the end of the eighteenth century that Lavoisier introduced the modern scientific spirit of exact measurement as applied to chemical phenomena and through it established the great reform responsible for modern chemical knowledge and research. Carbonic acid had already been discovered by Black, hydrogen by Cavendish, nitrogen by Rutherford and ammonia by Priestley; oxygen had been studied by Priestley, Scheele and Lavoisier, so that with Dalton's atomic theory, Cavendish's analysis of the air and Lavoisier's study of oxidation, definite knowledge of the chemistry of air and water, and of combustion and respiration was at hand for the use of the physiologist and physiological chemist. At about the same time the science of crystallography was established and somewhat later Davy's use of the electric current in the study of the alkaline earths.

In a word, activity in chemistry was evident everywhere, and theory and methods were being rapidly developed, but nowhere was chemistry a part of university study. Berzelius, Gay-Lussac and others had organized laboratories for the training of chemists, but it remained for the University of Giessen to establish the first chemical laboratory under the control of a university. Here, Liebig in 1826, when only 21 years of age, opened his laboratory and began his labors in organic chemistry.

The event is of importance, not only for chemistry, but for medical research in general, for the admission of chemistry to the university was the first step towards the overthrow of the "natur-philosopher" and hence to the development of that modern science which has made German universities so justly famous. It is also important from another point of view; in France science had been the work of the academicians, in England of workers in private laboratories or in those supported by commercial companies; by the new departure at Giessen, the precedent for university laboratories was established, and the world has since followed Germany's lead.

This laboratory of Liebig at Giessen was a success immediately and became the training school for most of the eminent chemists outside of Paris. The training offered at Giessen was systematic and methodical in qualitative, quantitative and organic analysis. In his autobiography, Liebig speaks of the difficulty "as the numbers increased, of the practical teaching itself" but "a progressive way of working" was thought out and tried, I can not refrain from quoting his own words concerning the development of the work in organic chemistry.

The first years of my residence at Giessen were almost exclusively devoted to the improvement of organic analysis, and with the first successes there began at the small university an activity such as the world had not yet seen. . . . Every one was obliged to find his own way for himself. . . . We worked from dawn to the fall of night, there were no recreations and pleasures at Giessen. The only complaints were those of the attendant, who in the evenings, when he had to clean, could not get the workers to leave the laboratory.

In another place he says:

I have found among all who frequent this laboratory (Giessen) for technical purposes a prominent inclination to occupy themselves with applied chemistry. They usually follow hesitatingly and with some suspicion my advice to leave alone all this time-absorbing drudgery, and simply to become acquainted with the necessary ways and means of solving purely scientific questions.

Such were the habits, the methods of work and the ideals of the man who in four years established that simple and accurate method of organic analysis known by his name. From his labors and those of Wöhler, who in 1828 announced the first synthesis of an organic substance (urea) dates our modern organic chemistry. Liebig representing the school of Gay-Lussac and Wöhler that of Berzelius, one at Giessen and the other at Göttingen, serve as an interesting example of scientific cooperation to develop a new science.

Liebig's work led directly to those activities which we now group under the term physiological or biological chemistry, but physiology was at this time making rapid strides along another line of attack—the application of the principles of mechanics and physics. The part of physics in medicine from Galileo to Roentgen is one of the most fascinating phases of the history of medicine; in principle and practise, in theory and science, its influence has been one of fundamental importance and in its application to methods of clinical diagnosis it shares equally with pathological anatomy in the awakening of modern clinical medicine. The first widely reaching application was in Harvey's interpretation of the circulation of the blood and the action of the heart, but it was not until organized physiological laboratories had been instituted that the application of the principle of physics bore abundant fruit. To recall the state of physics at that time it is only necessary to state that the work of Galvani and Volta was completed and that Ampère and Ohm, Faraday and Wheatstone, were still active. Charles Bell had already (1811) given to England the second of two great discoveries in physiology, the differentiation of sensory and motor nerves. Haller, as we have seen, had in the preceding century presented and discussed the

irritability of muscle. The time was at hand for the study of the general physics of muscle and nerve and the special senses. Ernst Weber announced the principles of his psycho-physics in 1825 and Johannes Müller those of his physical chemistry in 1826; Purkinjé had already established the first university laboratory of physiology in 1824 at Breslau; in 1838 the celebrated physiological institute at Berlin was formed under the direction of Müller and in 1840 Ernst Weber was made professor of physiology at Leipzig. From these two centers, Berlin and Leipzig, from Johannes Müller and Ernst H. Weber, came a great volume of minute investigations based on exact methods of inquiry. Both schools were largely busied with studies of the mechanism of the perceptions of the senses, that of Weber tending to include mental phenomena, thus anticipating the modern school of psychologists, that of Müller including not only the methods of physics, but also those of general biology. Müller (1801–1858) was indeed the last of a school which attempted to embrace all of the territory of biology in its broad sense; a territory which now has its separate and distinct fields of morphology, physiology and chemistry. He may, however, be regarded as responsible for some of the divisions into which the older biology has been split, and for the impulse to new lines of study, for he was the teacher of the masters who came in time to occupy high places in biology, of Schwann and Henle in anatomy, of Du Bois-Reymond and Helmholtz in physiology and of Virchow in pathological anatomy. It is not surprising therefore that it was the proud boast of this school that not only had it dispelled the vague notions of the old metaphysical school and established in its stead the true scientific spirit, but that it had filled so many of the chairs of medicine, physiology and anatomy in the German universities that the scientific spirit has been applied to "every branch of medical science, which it has in consequence drawn into the circle of the exact or mechanical sciences." (Merz.)

This is not the place to go into detail concerning the investigations of Müller and his school of physiology. His *law of "specific energies,"* Du Bois-Reymond's electro-physiology and Helmholtz's work on musical acoustics and physiological optics indicate the character and scope of the work. The keynote of it all Müller himself has expressed in his "Elements of Physiology" as follows:

> Though there appears to be something in the phenomena of living beings which can not be explained by ordinary mechanical, physical or chemical laws,

much may be explained, and we may without fear push these explanations as far as we can, so long as we keep to the solid ground of observation and experiment.

These principles and the labors of this school were advanced wonderfully, in 1847, by Ludwig's invention of the kymograph and the elaboration of methods of graphic registration, factors which established this phase of physiology on a sound basis and exerted an influence which medicine feels to this day. This, however, was not the only influence of Müller. As a biologist with general interests he stimulated general biological research and it was undoubtedly this influence exerted through Schwann that led the latter to grasp the importance of Schleiden's work on vegetable cells and to apply the observations of the latter to the cells of the animal body.

But although the cell doctrine, in its modern conception, is the result of the work of these two men, Schleiden and Schwann, it is not to be supposed that they were the first to study cells, for before Schleiden considerable attention had been given to the structure of vegetable tissues. Robert Hooke in 1665 had given to the spaces in cork and similar structure the names of "cells"; Malpighi (1674) and Grew (1683) had, as far as their low power lenses would allow, described plant tissue as made up in part of cell-like cavities provided with firm walls and filled with fluid, and in part of long tube-like vessels. Treviranus, in 1806, demonstrated that these tubes arose as the result of cells becoming attached end to end, the intervening ends eventually disappearing. The nucleus of the cell had been discovered in 1831 by Brown, who, however, failed to realize its importance. Not so Schleiden. He attached great importance to the nucleus and by the numerous observations (1839–1843) which he brought forward was able to formulate a definite cell theory for plants; later when this theory was applied to animal tissues and developed by Schwann and Virchow it became an influence as great as that of the theory of evolution, in the development of modern biology.

Schwann, who was at the time an assistant of Müller, received directly from Schleiden the impulse to compare animal and vegetable cells. While carrying out for Müller the experimental study of nerve and muscle, necessary for the proper preparation of his chief's great book on physiology, he became interested in the histological study of these structures and it was at this time that he described the nerve

fiber sheath which now bears his name. Once, when he was dining with Schleiden in 1837, the conversation turned to the nuclei of vegetable cells, Schleiden's description of these recalled to Schwann similar structures which he had seen in animal tissues. The resemblance between the animal and plant cells was, without loss of time, confirmed by both observers and the result was Schwann's famous paper (1839) on the accordance in structure of animal and plant tissues.

It is difficult for the student of to-day, thoroughly drilled concerning the details of cell structure in his courses in normal and pathological histology, to realize that only a little over 70 years ago the essential feature of the animal cell, the nucleus, was not recognized, and that it was a botanist who first brought the subject to the attention of a physiologist. Medicine in all its phases has advanced rapidly along the path thus opened up by Schleiden and Schwann. To-day we are interested above all other things in the chemistry of the cell, but from the time of Schwann to the time of Pasteur the study of the morphology of the cell in health and in disease was one of the chief interests of scientific medicine.

It is not to be supposed, however, that Schwann had the conception of the cell which we have to-day. He, as Schleiden before him, made faulty observations and drew faulty conclusions. The important features of Schwann's work were the recognition of the nucleus, not the cell wall, as the important part of the cell, the demonstration of the union or grouping of the cells to form tissues,[2] and the demonstration that the distinctive cells of the tissues of the adult develop from the undifferentiated cells of the early embryo. The misconceptions of the early histologists were natural when we recall the great technical difficulties with which they had to contend. The microtome, the microscope, and differential staining methods, in their present-day perfection did not exist for them. It was the day of the razor and hand sectioning. The first microtome appears to have been that used by Professor His in 1866; the improvements leading to the perfection of the present-day microtome did not begin until 1875. The development of the objective

[2] This statement does not disregard the work of Bichat (1771–1802), frequently called the "father of histology," to whom is due the credit of first recognizing the fact that the body was made up of distinct and differing tissues. Bichat's results, however, were obtained by the use of chemical reagents. He used the microscope but little, and his work, important as it was, and antedating the cell theory by 40 years, can not be considered as leading to the development of the cell theory.

of the compound microscope was just beginning in Schwann's time (1830). Although iodine was early used, it was not until about 1857 that Gerlach called attention to carmine, the first nuclear stain to be introduced into histological technic. At first, tissues were examined only in the fresh state and even later when hardened they were not imbedded as now in celloidin or paraffin, but placed between vegetable pith or blocks of amyloid organs during the process of cutting.

Surely the technical difficulties were great and we are not surprised that both Schleiden and Schwann believed new cells to be formed through a process of "crystallization" from a "mother liquor" or cytoblastema and that the cell was a vesicle with a solid wall. This question of minute structure and that of mitosis yielded eventually to improvements in technic and Schleiden's theory of the formation of cells *de novo* was discarded, and we know from Virchow's famous aphorism "*omnis cellula e cellula*" that in his time it was established that cells arose only by the division of preexisting cells. This general law was the result largely of the work of botanists, as Hugo von Mohl and Nägeli, and was applied by Virchow (1858) to animal tissues only after much work had been done on such tissues by Kölliker, Reichert and Remak. It was not until 1873 (Anton Schneider) that an insight into the details of cell division was gained and it was 1882 when the part of the nucleus in karyokinesis was satisfactorily demonstrated and Flemming could supplement Virchow's aphorism with another "*omnis nucleus e nucleo.*"

Thus did Schleiden, a botanist of the University of Jena, and Schwann, assistant (1824–1838) to Müller, establish one of the most brilliant and most important generalizations of the century, which became at once the basis of all morphological studies, and, as applied by Virchow, placed pathology on a scientific basis, and has continued as a result of its general biological applications—to development, inheritance and immunity—to influence medicine profoundly. As Verworn has said:

> It is to the cell that the study of every bodily function sooner or later drives us. In the muscle lies the problem of the heart beat and that of muscular contraction; in the gland cell resides the cause of secretion; in the epithelial cell, in the white blood corpuscle, lies the problem of the absorption of the food, and the secrets of the mind are hidden in the ganglion cell.

It will be necessary to return to the cell theory again in discussing the development of pathology, but we may leave it for the moment to

trace one other line of advance made by the physiologist; an advance in that phase of the subject which Du Bois-Reymond characterized, in 1880, as "vivisection and zoochemistry" in contrast to the electro-physiology of nerve and muscle with which his own name is so closely linked, and in contrast also to the phase of physiology in which histology, following the lead of Schwann, was playing so large a part. This third field in physiology necessitates a shift of scene to France and Claude Bernard and his school and the study of the functions of organs and their secretions.

Claude Bernard (1813–1878) was the pupil and successor of Magendie. Magendie did many things, but best of all he made "the experimental method the corner stone of normal and pathological physiology and pharmacology." (Welch.) By this method he demonstrated, as Charles Bell had divined, the essentially different functions of the anterior and posterior roots of spinal nerves. Also he founded a journal of experimental physiology.

Bernard, departing widely from Magendie's work, followed in his researches one main idea, the action of the nervous system on the chemical changes which constitute the basis of nutrition and this problem he attempted to solve by either direct experimental investigation of nerves, or by chemical researches or by a combination of both methods. His most important discoveries were the demonstration (1) of the significance of the pancreatic juice in digestion; (2) the glycogenic function of the liver and (3) the vasomotor system. These investigations (1850–1860) with those of Ludwig (1851) on the mechanism of the secretion of the glands, with the earlier observation on gastric digestion made by our own countryman, William Beaumont (1833), and the discovery of pepsin by Schwann (1835) represent the principles out of which our present conception of the physiology of digestion has developed. Not only did Bernard make discoveries and work out the lines of progress for the study of the outward or external secretions of glands, but as a result of his study of the influence of the liver on carbohydrate metabolism, he formulated the theory of "internal secretions," which represents a field of physiology cultivated in the past few years with the greatest success and still full of promise for the future.

Bernard has the distinction of being the first man of science to whom France accorded a public funeral, a recognition not alone of

personal worth, but also of the nation's debt to science and to research in the field of medicine.

Thus far I have presented the beginnings of those branches of medicine which deal with normal structure and function. Next in order of development comes that science which is concerned with the study of disease, pathology and upon which are based sound diagnosis and rational therapy and for this reason the science of most interest in medicine. Pathology owes its position as a recognized science to the genius of Virchow, but, in its development, it also owes much to the period I have just discussed, as I will show in due time. To present this development properly it is necessary to turn back to 1761 and Morgagni. I must again remind you that in Morgagni's time medical science can hardly be said to have existed. It was the period of a vague philosophy which attempted to systematize diseases according to symptoms, with no reference to the anatomical conditions causing the symptoms. It was Morgagni who first insisted that the clinical history should be set side by side with the results of the autopsy and who by his publication "De Sedibus et Causis Morborum" threw the first gleam of light on the causes and nature of diseased processes, and thus gave a stimulus to the study of pathological anatomy. Before Morgagni's time, and for some time after, pathological anatomy was mainly concerned with the recording of the rare and curious, with malformations and obvious departures from the normal type; observations oftentimes interesting, but not systematized or harmonized. Morgagni is responsible for the maxim that observations should be "weighed not counted," and it was undoubtedly this point of view which influenced his observations and led eventually to the doctrine that most diseases were to be explained by changes in the organs of the body.

Another step in advance was taken when Bichat, about a quarter of a century later, referred disease to the tissues of the organs. In the meantime John Hunter (1728–1793) had applied to the problems of clinical medicine methods which we now recognize as those of experimental pathology. Still pathology was not a science; it was not systematized and it had no underlying principle. The systematization of pathological anatomy came through Rokitansky[3] (1804–1878) and the underlying principle of pathology from Virchow in 1858.

[3] A worthy predecessor of Rokitansky was Johann Fr. Meckel, whose "Handbuch d. patholog. Anatomie" was published at Halle in 1804, the year of Rokitansky's birth.

Rokitansky, the father of pathological anatomy, was an assistant to Johann Wagner, later succeeding him in 1834 as prosector and finally in 1844 as professor of pathological anatomy at Vienna. Wagner had encouraged the application to pathology of the methods of anatomy, and the publication of Rokitansky's "Handbuch der pathologischen Anatomie," completed in 1846 (one year before Virchow's "Archiv" was founded), presented to the profession the results of a most thorough study of the details of pathological anatomy. It is said that Rokitansky performed, as the basis for his classifications, more than thirty thousand autopsies. His position in pathology has been likened to that of Linnæus in botany. "Even to-day nothing can equal the accuracy of Rokitansky's observations. There are few things he did not see. When some lesion or combination of lesions seems entirely new, it is often only necessary to go back to the work of Rokitansky to find that he had observed and accurately described it." (Councilman.) Although he encouraged the development of pathological histology, pathological chemistry and experimental pathology, he took no active part in these subdivisions of pathology and used the microscope but little. He seems to have been content with the establishment of pathological anatomy as a descriptive science.

Between Rokitansky's work and Virchow's cell theory there is no obvious connection. Between Morgagni, Bichat and Virchow we have an interesting link, that formed by the successive theories which placed disease in the organs, the tissues and the cell, respectively. Rokitansky worked with the organs and tissue and had no influence in carrying the quest on to the cell. The influences which led Virchow to the latter are wholly those we have discussed in the story of physiology and its beginnings, the personal influence of Johannes Müller, Schwann's writings and the results of the application to medicine of the methods of physics and chemistry. That he appreciated the importance of the relations of pathology, on the one hand, to physiology, and on the other to clinical medicine is shown in the title of his Archives established in 1847. It is not surprising, therefore, that he was not satisfied with the pathology as merely the descriptive and classifying science of Rokitansky and that he was the first to recognize that pathology was the study of life under abnormal circumstances, and that chemistry, physiology and embryology had a direct bearing on pathology and that the methods of all the other natural sciences should be applied to the elucidation of the problems of pathology and thus to those of medicine.

Virchow's "cellular pathology," as announced in its final form in 1858, must be considered as a general biological principle as important in the field of its application as Darwin's "Origin of Species" published one year later.

It is said that Virchow first began the observations which culminated in his doctrine of cellular pathology in his student days, while serving as an assistant in the eye clinic of the Berlin Hospital. Here he became interested in the fact that in keratitis and wounds of the cornea healing took place without the appearance of plastic exudate. This led to an investigation which indicated the occurrence of repair by the multiplication of preexisting cells. These studies led eventually to his theory, which Lord Lister has described as the "true and fertile doctrine that every morbid structure consists of cells which have been derived from preexisting cells as a progeny." In this theory he brought pathological processes into relation with normal growth, hence his axiom "omnis cellula e cellula." This was the underlying principle, which, following Rokitansky's work in classification, gave pathology a place among the biological sciences. With his cell doctrine as a guide he made many important contributions to histology both normal and pathological, and outlined a classification of new growths which is the basis of all present-day knowledge of tumors.

With his activities as anthropologist-archeologist we are not especially concerned except as they indicate the wide range of his interests. He was one of the founders of the German Anthropological Society, and later its president, and made expeditions with Schliemann to Troy, Egypt, Nubia and the Peloponnese.

Of vast importance to medicine, however, was his establishment of the first pathological laboratory, at the time he returned (in 1855) to Berlin from Würzburg after a political exile of eight years; an exile due to his sympathy with the revolutionary tendencies of 1848. This laboratory was the forerunner of the many which have been founded in the past fifty-five years in all parts of the world, and which have been found essential not only for the purpose of teaching and research, but also in the modern hospital. And again of importance is that influence exerted through his famous pupils such as Leyden, v. Recklinghausen, Cohnheim, Waldeyer, Kühne and Rindfleisch, to mention only the more prominent, who carried his views to other fields and continued his methods. Other great influences were to extend the territory of pathol-

ogy, as, for examples, Cohnheim's conception of experimental pathology, Weigert's tinctorial methods for the differentiation of cells and tissues, Ehrlich's application of these methods to the study of the blood, Metchnikoff's studies in comparative pathology, and finally the science of bacteriology; but with Virchow remains the credit of having established pathology as a science of university rank.

The third of a century beginning in 1828 with the founding of Liebig's laboratory and ending in 1858 with the publication of Virchow's doctrine of cellular pathology, represents a greater advance in the science of medicine than the combined activities of all the preceding centuries. What was the influence of these advances on the art and practise of medicine? Medicine at the beginning of the century was still influenced by the metaphysical treatment of scientific subjects. The previous century had been one of schools and systems, those of Cullen and Brown in England, Broussais in France and Hoffman and Stahl in Germany. It was also the time of Hahnemann (1753–1844) and the rise of homeopathy. The prevailing tendency was to base disease on the study of symptoms, without regard to the underlying pathological changes causing the symptoms. A few quotations may bring this period of change from the old to the new prominently before you.

Helmholtz writes of the period of his student life:

> My education fell within a period of the development of modern medicine when among thinking and conscientious minds there reigned perfect despair. It was not difficult to understand that the older and mostly theorizing methods of treating medical subjects had become absolutely useless. . . . We can not wonder if many honest, serious thinking men turned away in dissatisfaction from medicine, or if they from principle embraced an extreme empiricism.

And again he says:

> At that time there were many among the younger doctors who, in despair about their science, gave up all therapeutics, and took to empiricism.

This was from a scientific man, who had much to do with the changes about to come, and perhaps somewhat biased; but we have the view of Stieglitz, an "old and learned practitioner," expressed in 1840:

> German medicine was sunk so low and is so emasculated as to require any sort of shaking up. Whatever gives it a new direction will be wholesome, though new errors or possibilities may result therefrom.

But, to continue Helmholtz's remarks:

> The right kind of work brought forth its fruits much sooner than many had hoped. The introduction of mechanical notions into the theories of cir-

culation and respiration, a better insight into the phenomena of heat, the more minutely elaborated physiology of the nerves, speedily produced practical results of the greatest importance; the microscopical examination of parasitic tissues, the stupendous development of pathological anatomy, led irresistibly from nebulous theories to real facts.

As Helmholtz was born in 1821 his point of view is that of one who saw both the old and the new; the old in his student days, the new as one of those who labored to bring about the change. His view is largely that of the scientist, but we have fortunately the reminiscences of another, a practitioner of medicine, who labored as a student of medicine in those days of rapid change. I refer to Abraham Jacobi, our own Jacobi, "the father of pediatrics," who studied, as he tells us in his McGill address, "in three universities from 1847 to 1851, in Griefswald, Göttingen and Bonn." Referring to this period, he says:

I have lived under the eyes of and contemporaneously with great men and during the development of modern medicine . . . not as a cooperator, it is true, but as an interested looker-on, when great things happened.

Aside from Vienna, where Rokitansky taught, there were

only two places in all Germany in which pathological anatomy could be learned. One of them was Würzburg, there was Virchow, the other was Göttingen, there was Frerichs. So to Göttingen I went in search of pathological anatomy. . . . At the same time I looked for the advantages of chemical laboratory work under Wiggers and Wöhler.

Among the scientific happenings of Jacobi's first medical year (1847) are the following: Helmholtz's address on the conservation of energy; the use of ether anesthesia in obstetric practise by Hamner and in dentistry by Delabarre (first used by Warren at Boston in 1846); Liebig's researches on meats; the employment of prismatic glasses by Kreke and Donders; the first use of chloroform by Simpson; the employment by Duchenne of faradization in the treatment of paralysis; the discovery of unstriped muscle fibers by Kölliker and the studies by Semmelweis of the etiology of fever in puerperal women.

Among the events of the next five years, during three of which he was a student and two a political prisoner, Jacobi mentions: Bunsen's quantitative analysis of urea, the founding of spectral analysis, the use of cold for anesthesia, Claude Bernard's puncture of the fourth ventricle and his demonstration of the glycogenic function of the liver and of the vasomotor nerves; the discovery of *Trichophyton tonsurans* and *Balantidium coli* by Malmsten, the invention of the spirometer by Hutchinson and of the ophthalmoscope by Helmholtz, and the sphygmograph by

Vierordt. Altogether Jacobi tells of a host of observations made in a short period of six years. And the list is not one of laboratory discoveries only. It includes important advances in clinical medicine and surgery, as Meigs's discovery of the importance of thrombosis as a cause of death in puerperal women, Marion Sims's vesico-vaginal operation, Detmold's operation for abscesses of the cranial cavity, Walker's work on the infectious nature of secondary syphilis, Romberg's studies of tabes dorsalis, Pravaz's invention of subcutaneous injection, Kuchenmeister's discovery of the connection between tænia and the scolex found in pork, Bigelow's resection of the femur and Bennet's work on leucocythemia.

More could be quoted from Jacobi's impression of this period, but this is enough to show that medicine was advancing not only in the laboratory, but in the clinic. One may, as Jacobi says, "recognize in my fragmentary enumeration, facts of crucial import."

These advances in clinical medicine and surgery were due to several factors; to the increasing use of the methods of physics, chemistry and biology, to the influence of pathology, to the introduction of new procedures in diagnosis, and in surgery, to the facility of operation offered by anesthesia. What a change in the practise of medicine these observations and applications brought about! How different their influence from that of the earlier schools and systems with which we associate the names of Brown, Cullen, Broussais, Hoffman and Stahl!

Such schools and systems, while of interest to the general historian of medicine, offer no assistance to one seeking the lines of advance dependent on investigation or research in medicine. Fortunately for the history of clinical medicine the systematists did not occupy the field to the exclusion of those guided by objective observation, for we find Sydenham (1624–1689) and Boerhaeve (1668–1738) studying disease unbiased by schools or systems, and applying the methods of close observation which we now recognize as those of modern clinical medicine. But although Sydenham and Boerhaeve and their followers aided progress by the addition of some positive knowledge to clinical medicine, their influence on the development of medicine was not great, for they were before the days of Morgagni, Haller, Hunter, Bichat and Rokitansky and the methods associated with these names.[4] Without patho-

[4] Before and about the time of the period so represented, some of the important contributions made to clinical medicine and pathological anatomy were as

logical anatomy clinical classification was impossible, and without physiology and the methods of the physiologist, clinical interpretation was difficult. The influence of pathological anatomy on clinical medicine was felt first in England through Baillie (1761–1823), a pupil of Hunter; in France, after Bichat, through Louis, Andral and Lænnec; in Germany through Schönlein and Romberg; and in America through the pupils of Louis. The discovery of the diseased conditions with which we associate the names of Bright, Pott, Addison, Graves, Stokes and Hodgkins came at this time, as also Marshall Hall's discrimination of diseases of the spinal cord and Bayle's study of tuberculosis of the lung. It was the period when the best members of the profession endeavored to give to the study of symptoms the same precision as characterized anatomical observation and to combine the results of this method with the revelations of pathological anatomy. It was this method that culminated in Louis's so-called "numerical or statistical method," the method of basing conclusions on large groups of records rather than on isolated observations, and which, in this country, through the work of two of Louis's students, Gerhard and Stillé, led to the differentiation of typhoid fever from typhus fever, with which it had been confounded.

But of equal importance was the second influence which was at work, that of improved methods of diagnosis of diseases of the heart and lungs, the methods of percussion and auscultation. Percussion was first used by Auenbrugger, in 1761, but was treated with contempt and ridicule until 1808 when his pamphlet was translated into French by Corvisart, who proclaimed the value of the method and obtained for it universal recognition. Shortly after, in 1819, came Lænnec's work on the use of the stethoscope in auscultation, and Skoda in 1839 did much to extend the use of both percussion and auscultation.

This phase of medicine, the development of instruments and means of studying diseases of the internal organs and the organs of the special senses—the history of the stethoscope, the ophthalmoscope, the laryngoscope, and like instruments—is a most fascinating subject and one worthy of extended treatment, but it must suffice here to state that the

follows: aneurism and diseases of the heart by Lancisi, Albertini and Senac; an investigation by Fothergill, of the diseases now known as diphtheria and tic douloureux; of prison and camp fevers by Pringle, of epidemic fevers by Huxham; of diseases of the skin by Willan, of angina pectoris by Heberden, and of gastric ulcer by Baillie.

new methods of direct exploration brought about a complete revolution in the knowledge of disease and had "more influence on the development of modern medicine than all the 'systems' evolved by the most brilliant intellects of the eighteenth century." (Payne.)

Exact clinical observation, the study of pathological anatomy and the increasing use of instruments and methods tending to accuracy in diagnosis were, therefore, the characteristic features of the early nineteenth century school of medicine. Both medicine and surgery were developing along lines which ensured accelerated progress under the impetus of the discoveries in bacteriology which were soon to follow, and we could with propriety pass on to the era of bacteriology, if it were not for one great boon, destined to have an enormous influence on the practise of surgery, on the diminution of human suffering and on the general advance of research in medicine. This was the introduction of anesthesia. Surgery had steadily advanced in technic, resourcefulness and daring, but the torments of surgery were such that operations were mainly those of necessity. As Mumford says:

> Surgical pain was real enough; there was no disguising it. The terror of operation was a very hell, even in anticipation; the fact itself no man has found words to describe. The shadow of it has lengthened even to our own day. Surgeons as well as patients dreaded the knife.

Robert Liston, two years before the discovery of ether congratulated his students that the "field of operative surgery" was "happily narrowed." Keen writes:

> It is a striking commentary on the immediate results of anesthesia to learn that, in the five years before the introduction of ether, only 184 persons were willing to submit themselves to such a dreadful ordeal in the Massachusetts Hospital, an average of 37 operations per annum, or 3 per month. In the five years immediately succeeding its introduction, although the old horror could not be overcome, 487 operations, or almost 100 annually, were performed in the same hospital. During the last year (1898) in the same hospital 3,700 operations were performed.

This change was brought about in 1846, when W. T. G. Morton, an American dentist, by publicly administering ether, proved to the world that it was a safe and sure anesthetic. The operation was performed by John Collins Warren at the Massachusetts General Hospital and the names *anesthesia* and *anesthetic* were suggested by Oliver Wendell Holmes. Anesthesia was therefore essentially a Boston affair as far as its introduction to the world was concerned, but the claims of its discovery made by others (Long, Jackson, Wells, Marcy) leave the

question of priority in the knowledge of and use of ether in much confusion. With this phase we are not at present concerned. One year after the demonstration in Boston, Simpson, of Edinburgh, recommended chloroform as an anesthetic of equal value with ether. Not only surgery but obstetrics, dentistry and the various specialties benefited by this great boon of anesthesia and within a year the administration of anesthetics was a universal practise throughout the civilized world. Surgery, freed of its horrors, developed along lines hitherto undreamed of, and made those rapid strides which prepared it for the era of antisepsis in the next generation.

The next lecture will concern itself with the story of Pasteur and the development of bacteriology and the influence of the latter on medicine and surgery.

LECTURE III

Pasteur and the Era of Bacteriology

The story of bacteriology can best be told by recounting the labors of Pasteur, for while bacteria were known and theories of infection had been elaborated and vaccination practised before his time, it was he who definitely established the importance of bacteria in putrefaction, fermentation and disease, and gave to vaccination a scientific basis. The influence of these labors is comparable in medicine only to that of Virchow in his field and is as great as that exerted in general biology by Darwin's researches. The story of rapid sequence of Pasteur's brilliant discoveries in science, each of crucial importance and establishing a new principle have, I believe, no parallel in biology or, for that matter, any other science.

But before presenting Pasteur's labors it is necessary to outline the knowledge of bacteria and the theories of fermentation, infection and allied processes which were current at the beginning of his era.

Bacteria were first seen by Leeuwenhoek, a Dutch léns-maker in 1673. This was long before the day of the compound microscope, but Leeuwenhoek was able to make such excellent short focus single lenses that he could study red blood corpuscles and spermatozoa, detect minute globular particles in yeast, and, as we know from his drawings, even discover some of the larger microorganisms in the tartar of the teeth,

in saliva and intestinal and other fluids. In 1838, about the time of the development of the compound microscope, Ehrenberg attempted a classification of bacteria based on sixteen species. Our exact knowledge, however, begins with Cohn's studies which extended from 1853 to 1875, and were the first to differentiate between the spherical forms which we call cocci, and the rod-like forms or bacilli. These early studies were almost exclusively botanical in nature and it was not until 1872 that Cohn could include definite disease-producing bacteria in his classification of the vegetable microorganisms.

Bacilli had been found, it is true, as early as 1850 in diseased animals, for example, the anthrax bacillus in animals dying of splenic fever. So also Schönlein in 1839 had discovered a vegetable parasite, a mycelial form, higher than the bacteria, in the disease of the skin known as favus; Malmsten in 1848 had found a somewhat similar form in barber's itch, and Bassi about 1832 had demonstrated that a disease of the silkworm was due to a minute cryptogamic plant. But the importance of these observations was not widely appreciated and no general relation was established between bacteria and disease in man.

Likewise, theories of infection which explained disease as due to invisible microorganisms had been propounded as early as 1762, as for example that of Plenciz, which, based on Leeuwenhoek's discoveries, ascribed to every disease its particular microorganism, explained the decomposition of animal and vegetable material as due to microorganisms, postulated the growth of bacteria in living tissues and suggested the possibility of the transmission of disease virus by the air. Such views, naturally, were without experimental basis and without even an objective knowledge of the microorganisms supposed to be etiologically concerned. In other words the propounder of this theory, as others after him, believed more than he could prove. By the middle of the century, however, observations on bacteria, largely as the result of the labors of botanists, were accumulating, and views about spontaneous generation, fermentation and infection were being discussed, but the fundamental experiments necessary to settle these problems were yet to be made, and, curiously enough, it was a chemist, influenced by the methods of physics, who was to establish bacteriology as a biological science and to give to it the important place in medicine which it has occupied for the past thirty years.

Pasteur was this chemist, and his first great discovery was in crys-

tallography, the explanation of the behavior of one of the tartaric acids to polarized light. This acid obtained from the lees of wine was, unlike other acids of the group, inactive to polarized light. This inactivity Pasteur demonstrated to be due to the fact that it was made up of two isomeric constituents. The crystals of one of these constituents bore hemihedral facets on the right side and rotated the plane of polarized light to the right, and those of the other bore similar facets on the left, and therefore, rotated to the left, but, as Pasteur found, when combined, these crystals did not rotate the plane of polarized light at all. This, the first of his discoveries, was in 1848, the year that Virchow was investigating typhus fever in Silesia. If it is necessary to fix contemporary events more definitely I may introduce the fact that two years later Pasteur quotes Professor Biot as referring to his recent discoveries in crystallography as "a very California."

Now, this work of Pasteur on the tartaric acids not only opened a new field in crystallographic studies, but, of far greater importance, led to the discoverer's studies in fermentation. In the course of his work on the tartaric acids he found that if salts of the inactive acid were acted upon by a mould (*Penicilium glaucum*) the right-handed constituent was destroyed, but the left-handed remained unchanged; and from this he concluded that the change from an optically inactive to an optically active fluid, under such experimental conditions, could be due only to the presence of living matter causing the destruction of one component. This was the beginning of his studies of fermentation, and from this time his labors were those which eventually established the sciences of bacteriology and immunity.

The opportunity to study alcoholic fermentation came at Lille in 1854, at a time when Pasteur was professor of chemistry and dean to the faculty at that place. The manufacturers of the region had met with disappointment in the making of alcohol from beets, and one of them came to the new professor of chemistry for advice. Pasteur undertook daily visits to the factory and from these visits came the idea of studying the fermenting beet juice in the laboratory.

Fermentation, at the time Pasteur entered the field, was a subject involved in great obscurity, with only here and there a ray of light. Cagnaird-Latour, in 1836, had studied that ferment of beer called yeast, and had observed that it was composed of cells "susceptible of reproduction by a sort of budding, and probably acting on sugar through

some effect of their vegetation." Schwann and Kützing a few years later reached the same conclusion, but were opposed at once by Liebig, who enunciated a theory of mechanical decomposition and denied in its entirety the theory that fermentation was a biological process. Also Berzelius, second only to Liebig as an authority, believed fermentation was due to contact, and elaborated a theory of catalytic force. With such weighty opposing opinion the observations of Cagnaird-Latour and Kützing were neglected and fermentation was regarded by all as a strange and obscure process and was so characterized by Claude Bernard in 1850.

Uninfluenced by these views, however, Pasteur, having recognized that living matter is essential for alcoholic fermentation, adhered strictly to the experimental method, and taking up the problem of lactic acid fermentation (the souring of milk), discovered that the same budding and multiplying of a cell went on in it as in alcoholic fermentation, but that the cell of lactic acid fermentation was different from that of alcoholic fermentation. He observed also that the form of the cells changed according to the conditions of fermentation. Incidentally he demonstrated in alcoholic fermentation, the formation of glycerin and succinic acid in addition to the well-known products alcohol and carbonic acid. In short, the outcome was that Pasteur completely demonstrated that the fermentations which lead to the production of alcohol, vinegar, lactic acid and butyric acid are all due to the presence and growth of minute organisms, or, in his own words, "The chemical act of fermentation is essentially a correlative phenomenon of a vital act beginning and ending with it."

The demonstration of the part played by specific microorganisms in the different fermentations was, as may readily be seen, suggestive of the etiology of infectious diseases. It was in the midst of these labors that the Académie des Sciences conferred upon Pasteur the Prize for Experimental Physiology (for 1859), and it was Claude Bernard who drew up the report and dwelt upon the "physiological tendency in Pasteur's researches." Ten years before, Bernard had characterized the process of fermentation as "obscure."

The results of the investigation of fermentation led naturally to a debate among the academicians concerning spontaneous generation, and in this dispute Pasteur took a most important part. The older examples of spontaneous generation, as, for example, the development

of mice from a mixture of soiled linen and cheese and of maggots from decomposing meat, had long been discarded, but the demonstration that fermentation and putrefaction were due to microscopic living organisms raised the question: Whence comes this microscopic life? Do or do not these bodies arise spontaneously in putrescible and fermentable fluids? The results of several investigations were already at hand. Thus Spallanzani (1769) had shown that if a putrescible fluid was hermetically sealed in flasks and the flasks heated in boiling water, decomposition did not occur; Schulze (1836) had obtained the same result by filtering through strong solutions of acids and alkalies the air which entered such flasks, as had also Schwann (1837), by first passing the air through heated tubes; and likewise Schroeder and Dusch (1854) by filtering the air through cotton plugs. All these procedures robbed the air of the suspended microorganisms and, as the fluids had previously been sterilized by heat, decomposition did not occur. But at the time these procedures, though now recognized as the basic principles of bacteriological technic, as applied to sterilization and asepsis, did not gain general credence. "Philosophic argumentation always returned to the fore." The theory of spontaneous generation would not down, and from 1858 to 1862 it was the most important matter of debate in the discussions of the Académie des Sciences.

Pouchet and Pasteur were the disputants, the former defending the thesis that "animals and plants could be generated in a medium absolutely free from atmospheric air, and into which, therefore, no germ or organic bodies could have been brought by the air"; the latter insisting that only through the entrance of such living organisms could the changes in question take place. The discussion lasted several years, and to-day presents many interesting details, but it may suffice to state that it was ended by Pasteur's demonstration that if the neck of a flask was drawn out into a fine tube and bent into a double curve and the flask then heated by boiling, no decomposition occurred. The flask was open to the atmospheric air, but the microorganisms of the air were arrested by the drop of water of condensation, in the lower point of the curved neck. This demonstration, with the later work of Cohn on spores and of Tyndall on floating matter in the air, disposed of the doctrine of spontaneous generation and led to the universal acceptance of Harvey's law *Omne vivum ex ovo,* or as it was modified, *Omne vivum ex vivo.*

It is not surprising that Pasteur at this time foresaw the possibilities in the study of the etiology of the infectious diseases. The process of fermentation, due to living microorganisms, and beginning with a period of apparent inactivity, passing on to a stage of very evident activity and finally sinking gradually into quiescence, was analogous to the period of incubation, the stage of active manifestations and the gradual defervescence of an infectious disease. Also the specificity of the ferments was evidently suggestive of the specific etiology of disease, and altogether we see from several of Pasteur's statements at this time that the relation of microscopic organisms to disease occupied his mind. Thus in a letter to his father, in 1860, he expressed the hope that he may, "bring a little stone to the frail and ill-assured edifice of our knowledge of those deep mysteries of Life and Death where all our intellects have so lamentably failed" and in 1863, after an audience with Napoleon III., he writes, "I assured the Emperor that all my ambition was to arrive at the knowledge of the causes of putrid and contagious diseases."

And now with that peculiar trick of coincidence that is so surprising in the course of culture and inquiry, we find that about this time bacteriology began to make advances along three general lines of study: (1) The etiology of the acute infectious diseases; (2) the prevention of infection, and (3) the achievement of cure or immunity by vaccination. In the first and third of these, Pasteur played a prominent part and it was his work on fermentation which suggested the second to Lister. Pasteur's entrance into the field of etiology and the results he there accomplished form one of the most interesting phases of the history of science and its outcome, a matter of the greatest economic importance to France. The opportunity to study an infectious disease was offered by an epidemic of a mysterious disease which was ruining the silkworm industry. Whence the disease came or how it was contracted no one knew. Its onset was recognized only by the presence of the little brown or blackish spot from which it got its name (pébrine). Pasteur, who undertook the investigation at the request of his old master Dumas, now a senator, knew nothing of the industry and, as he wrote Dumas, "had never touched a silkworm." But under pressure of Dumas's solicitation he finally yielded, and found himself, a chemist, hitherto interested chiefly in the study of crystallography and fermentation, thrown at once into a new and strange field. That his re-

sults were due largely to the training and the point of view obtained through the study of fermentation and the use of the microscope, there can be little doubt, and one is inclined to apply to Pasteur at this stage of his work his own statement of ten years before; "in the fields of observation, chance favors only the mind which is prepared."

Once in the silkworm country he applied himself energetically to the study of the "fatal spots." The story of the complete investigation is a long one, but the main points are that within a month he found that although worms, moths and eggs were infected, the critical stage was the infection of the moths, and that, in these, the infection could be readily demonstrated with the aid of the microscope, and, that having demonstrated this, the remedy lay in using the eggs of non-infected moths only. Thus a new breed of worms free from infection could be obtained and the extension of the disease arrested. In the course of this work he reproduced the disease experimentally by feeding healthy moths with infected mulberry leaves, a novel procedure then, but one, which, with its modifications, was soon to become a commonplace principle of bacteriological investigation. The investigation of the silkworm problem lasted for five years, or until Pasteur cleared up not only the difficulties connected with pébrine, a disease due to infection with a psorosperm, but unmasked also a second disease of the silkworm (flâcherie), a bacterial infection of intestinal origin.

In the meantime Pasteur continued his studies of the diseases of wines (sour, bitter and muddy wines) and invented the process known then and now as "pasteurization." This was the simple process of heating the wine in order to free it of all germs of wine disease and make it suitable for storage and exportation. In this connection he expresses the greatest satisfaction that he was thus able to contribute to the national riches through the practical application of his observations. In 1867 he said:

> **Nothing is more agreeable to a man who has made science his career than to increase the number of discoveries, but his cup of joy is full when the result of his observations is put to immediate practical test.**

The term, pasteurization, is now most frequently heard in connection with milk, but when it is recalled that all commercial and domestic methods of canning and preserving solid and fluid foods are based on the laboratory experiments of Pasteur one obtains an adequate idea of the importance of his observations and likewise appreciates his satisfaction at the practical application of his methods.

As the silkworm problem began to clear up, Pasteur's thoughts turned more and more to the etiology of the acute infectious diseases of man and animals and their experimental study. This is shown in his appeal to the government (1867) for a laboratory. In this appeal he refers to the advisability of investigating splenic fever and asks, "How can researches be attempted on gangrene, virus or inoculations, without a building suitable for the housing of animals?" and in 1871, in his book on beer, with the diseases of which he had busied himself, we again find a reference to the possibility of the disease of man and animals being due to microorganisms. Here again it is evident that he was influenced by the idea of microorganisms invisibly introduced into fermentable fluids, for in this connection he says, "it is impossible not to be pursued by the thought that similar acts may, *must*, take place in animals and in man"; but without experimental proof he refused to go further.

Pasteur's attack on animal diseases was, however, delayed, first by a cerebral hemorrhage in 1868 which left him partly paralyzed, and then by the Franco-Prussian war which interrupted all scientific efforts in Paris.

Here it is well to pause a moment to consider the attitude of the medical profession towards the theory which was beginning to take shape as the "germ theory." The following decade was to see the bacterial etiology of several important diseases established, Lister's practise of antisepsis in surgery quite generally accepted, and the principle of specific vaccine treatment demonstrated. To-day no phase of medicine is so well understood by the world at large as that of bacteriological principles and aims. Germs and sera, prophylaxis and quarantine, antisepsis and pasteurization, are matters of common knowledge and of ordinary conversation, but it is difficult for one unfamiliar with pre-bacteriology days to appreciate the views which had to be combated only forty years ago. A brief glance at the conditions in 1873 may therefore give you a better appreciation of the events of the succeeding decade. If it is necessary to fix the period, let me remind you that 1873 was the year the University of California removed to its present site.

The Franco-Prussian war had come to a close. Surgeons remembered that though soldiers were killed in battle by tens and hundreds, they died of surgical diseases by thousands.

> In the hospitals surgical sepsis ran rampant. Secondary hemorrhage, erysipelas, pyemia and "hospital gangrene" were endemic. Sometimes wards, wings or whole institutions were closed in vain attempts to stamp out these disorders. (Mumford.)

The causes were unknown and the remedies, therefore, not at hand. Of this period we read with amazement that

> Sometimes a surgeon would wear the same old operating coat for years, and would pick waxed ligatures from the button hole of his assistant who carried them there for the convenience of his chief. (Mumford.)

To-day, we refer to it as "a barbarous era," but before Lister the most conscientious surgeon had no reason to do otherwise than has been described.

And, likewise, internal medicine, although it had benefited by improvements in the methods of physical diagnosis and by the application of the principles of pathological anatomy, had made no progress in the prevention and treatment of the infectious diseases. In the presence of these scourges of humanity the physician was not only helpless, but indifferent to the occasional illuminating discoveries of the exact thinker or investigator. Many examples of this indifference are at hand. In the writings of Henle (1840–1853) was announced a rational theory of infection, but it was ignored. Oliver Wendell Holmes (1843 and 1855) had brought forth a great body of facts indicating that puerperal fever was "so far contagious as to be carried from patient to patient by physicians and nurses," and Semmelweis in 1847, working in the old Vienna hospital, had asserted that the mortality from this disease could be reduced from 12 and 16 per cent. to 3 per cent. (later he reduced it to less than 1 per cent.) by the simple procedure of cleansing, in a solution of chlorinated lime water, the hands of those concerned in obstetrical work. The views of Holmes and Semmelweis, however, were ridiculed and the simple antiseptic procedure of the latter was not continued, and when Villemin, thirteen years before Koch discovered the tubercle bacilli, demonstrated by exact experimentation the transmission of tuberculosis to animals, and announced that the disease was a specific transmissible disease, "he was treated almost as a perturber of medical order." I know of nothing which so clearly shows the state of mind of the profession of that day as the remark of Pidoux in criticizing Villemin's work. Referring to the doctrines of specificity he says,

> These doctrines condemn us to the research of specific remedies or vaccines and all progress is arrested. . . . Specificity immobilizes medicine.

This representative of traditional medicine could see no relation between Villemin's experiments in which guinea pigs were brought into contact with the dried sputum of tuberculous patients and Pasteur's theory of germs floating in the air being responsible for the various fermentations.

So, likewise, it was with Davaine's demonstration (1863) of bacteria in the blood of animals dying with anthrax. His view that these micro-organisms, multiplying rapidly in the blood, were in their action analogous to Pasteur's ferments and responsible for the death of the animal, was received only with arguments and did not immediately stimulate investigation, despite his proof of experimental production of the disease by inoculation. To us, who know to-day the fruits of the study of specific etiology and specific therapy, the opposition to the views of Villemin and Davaine and others is almost incomprehensible, but it must be remembered that these views were the fruits of a new type of investigation in practical medicine, that of laboratory research which came close to the sacred precincts of the clinic. "This was the time," in France at least, "when the 'princes of science' or those who were considered as such, were chiefly physicians. The almost daily habit of advising and counselling" gave them a haughty superiority, and views not based on clinical researches were set aside as unsound. Physiology and chemistry applied to the normal individual were well enough, and pathological anatomy with the post-mortem room as an adjunct to the clinic was very proper, but for the laboratory investigator to invade the clinic and present his views concerning the cause of disease or to explain its phenomena was another matter. A well-known surgeon of that time stated:

> Laboratory results should be brought out in a circumspect, modest and reserved manner, as long as they have not been sanctioned by long clinical researches.

But at the very time (1873) of this statement, the forces which were to make the era of laboratory research the greatest of medical eras were already at work; Hoppe-Seyler was establishing (1872) the first laboratory of physiological chemistry, v. Recklinghausen was studying the wanderings of the white blood cell, Weigert was staining bacteria with carmine, Ehrlich was applying dyes to the study of the cells of the blood (both later developed the use of the aniline dyes in histological and bacteriological technic), Abbe was developing his condensing system

of illumination for the microscope, Cohn was classifying bacteria according to their morphology, Klebs was separating bacteria from their culture fluid by filtration through animal cells, Pettenkoffer was studying the relation of water to epidemics of typhoid fever and cholera, Obermeier had found a parasite in the blood of relapsing fever, and Koch, a country physician, was carrying on those early researches which were soon to make him the leader in the science of bacteriology. At the same time (since 1866), pathologists (Rindfleish, v. Recklinghausen, Waldeyer, Birch-Hirschfeld and Klebs) had been examining individuals dying of septicemia, pyemia, erysipelas, abscess, inflamed wounds, etc., and had found bacteria in all these lesions, Birch-Hirschfeld, moreover, had called attention to the resemblance, in pyemia, between the bacteria of the local lesion and those in the internal organs, and had observed bacteria within the leucocyte. To us, who view these activities in retrospect, they are phases of a general advance, the culmination of which is common knowledge, but in the early seventies they were merely the non-related efforts of individual workers. Some practical demonstration was necessary to give to the newer type of laboratory work an importance which would impress the profession. Such a demonstration came through Lister's antiseptic treatment of wounds and was followed shortly by the observations of Koch on anthrax, and of Pasteur on vaccination against bacterial disease.

Lister's first publication concerning his treatment of wounds was in 1867, but it was not until the late seventies that his views were quite generally accepted. In the meantime his methods and their results served to concentrate attention on bacteria and their relation to the diseases of man. He regarded wound infection as putrefaction due to the invasion of the wound by minute microorganisms of the air; a conception which, as he acknowledges in his first publication, was suggested by Pasteur's work on fermentation. In a letter to Pasteur in 1874 he offers "most cordial thanks for having demonstrated to me the germ theory of putrefaction, and thus furnished me with the principle upon which alone the antiseptic treatment can be carried out."

His method was to combat this air-borne infection with an antiseptic—carbolic acid. He cleaned a wound by wiping it out with carbolic acid and then sealed it with lint soaked in this acid. All instruments, sponges and dressings coming in contact with the wound or the hands of the operator or assistants, as well as the site of operation, were

cleansed in the same way. Also, by means of a vaporizer, carbolic acid was sprayed into the atmosphere about the site of operation. As years passed the details of this method changed. We now speak of the suppuration of wounds, not of putrefaction; the carbolic spray has been abandoned and our ideas about sepsis have been modified in several ways, but the principle remains as Lister conceived it. The beneficial results of this new treatment in Lister's hands were immediate, but its general application came slowly. We find Pasteur in 1874 referring to Lister's "marvellous surgical methods" and recommending to the surgeons of Paris the use of instruments and dressings sterilized by heat. The complete acceptance of Lister's principle would appear to correspond to the year 1883, when he was made a baronet.

The benefits of antisepsis are now so familiar to us, and its use so much a matter of routine, that we cease to wonder at the revolution it brought about in surgery. Some diseases, as hospital gangrene, it has abolished entirely; others, as the septic surgical diseases of former days, have been reduced almost to nil; it has robbed the period of child-bearing of one of its chief perils, and has opened to surgery regions and cavities of the body previously closed on account of the great mortality due to sepsis. Antisepsis shares with anesthesia, as its discoverer, Lister, shares with Morton, Warren and Simpson, the honor of the great advances surgery has made in the treatment of disease and injuries of the abdomen, thorax and the cranial cavity. Who can compute the relief from suffering and the saving of life which may be traced through Lister to Pasteur's laboratory experiments on fermentation?

The recognition of the principle of asepsis by the surgeons was, then, as we have seen, slow and grudging enough; among the profession at large the theory of infection as applied to acute diseases gained more slowly still. It was not until 1880 that advance in the knowledge of the bacterial etiology of infectious diseases assumed such definite shape as to attract general attention. As we look back upon this early work we see clearly that one reason for this slow advance was the absence of proper methods of isolating bacteria in what we now call pure cultures. Pasteur and his co-laborers made (1) direct search for bacteria in the secretions, blood or tissue juices, or (2) inoculated fluid media or animals with such material. By the first of these methods it was possible to recognize bacteria if they were especially abundant, as in

anthrax, and it was by this method that Neisser discovered the gonococcus (1879) and Hansen the leprosy bacillus (1879), bacteria which are particularly abundant in the local lesions of the respective diseases. The second method, the use of fluid media, was satisfactory if the material for study contained only one type of organism; if more than one it was obviously difficult to study the life history of a bacterium or to obtain exact results by the inoculation on account of the simultaneous growth of associated or contaminating organisms. This difficulty was overcome by Koch, in 1881, through the introduction of solid culture media. Koch had already, while a country practitioner, definitely and clearly established the relation of the anthrax bacillus to the splenic fever of cattle and had demonstrated in this organism the formation of spores and their importance; also he had published most important observations on the bacteriology of wound infection. The use of solid media, which it is said was suggested to Koch by the growth of mould on potato, led at once to rapid advance, for as each bacterium placed on a solid medium causes, as it multiplies, the growth of a visible colony, it was possible to distinguish colonies having different characteristics and by transplantation to secure pure cultures. The demonstration of Koch's solid media and plate method at the Congress of Hygiene in London in 1881 caused Pasteur to exclaim "C'est un grand-progrés." This advance and the use of microscopes equipped with the oil immersion lens and the Abbe condenser, and the increased knowledge concerning the use of the aniline dyes for staining purposes gave to bacteriology the technic necessary for its rapid development. Koch was called to the Imperial Board of Health in Berlin in 1880, and started the first laboratory founded for the study of bacteriology and public health problems. In this laboratory, methods of studying and photographing bacteria were developed, methods of disinfection based on the knowledge of spore resistance were elaborated, and the study of the bacteriology of individual diseases inaugurated. As a result of the latter activity, he announced, in 1882, the discovery of the bacillus of tuberculosis, and it is not too much to say that his announcement astounded and profoundly stirred the entire civilized world. In the same year Löffler and Shütz announced the discovery of the bacillus of glanders, and Pasteur published an account of the bacteriology of swine erysipelas; this was the beginning of an active period with discovery crowding on discovery. In 1883 came Koch's announcement of

the comma bacillus as the cause of cholera; in 1884 Löffler's description of the bacillus of diphtheria and Nicolaier's discovery of the bacillus of tetanus. So the march of discovery continued until the roll of diseases of known etiology in a short time included typhoid fever, pneumonia, meningitis, influenza, bubonic plague and the various surgical suppurations.

The rapid discoveries of disease-producing microorganisms established definitely Pasteur's doctrine of specificity as applied to etiology and led at once to an interest in public health measures which increased as the years passed, until now it has become one of the most vital interests of our social system. Even in the early eighties, with a knowledge of the etiology and mode of transmission of a few diseases and of Lister's results in antiseptic surgery, it was possible to postulate general prophylactic measures safeguarding the individual and the community, and as knowledge of etiology and transmission increased, so did prophylaxis. Hygeia was again enthroned and it was recognized that "an ounce of prevention is worth a pound of cure."

But prophylaxis was not entirely satisfying. If a specific etiology, why not a specific therapy for bacterial diseases? Men remembered inoculation for smallpox introduced into England by Lady Mary Wortley Montagu early in the eighteenth century. This procedure, the inoculation of healthy individuals with material from the pustules of those ill with a mild form of smallpox had materially reduced the fatality of the disease. The procedure, it is true, had been made illegal in England in 1840, because of the greater success and less danger of Jenner's wonderful discovery (1798) of vaccination with the fluid of the pustule of cowpox. Inoculation, however, despite the fact that it sometimes caused severe and fatal cases of smallpox and perpetuated foci for the dissemination of the disease, had demonstrated that the mild inoculation disease usually protected against the more severe forms. That Jenner's vaccine was a transmitted cowpox did not militate against the general theory of protecting the individual against a severe form of a disease by the production of a mild form, for cowpox was generally considered to be smallpox modified by passage through another host, the bovine animal. If such results could be obtained against a disease, small-pox, the causal agent of which was unknown, how much easier to vaccinate against a disease of known etiology!

This was therefore the first line of attack in the battle for a spe-

cific therapy of the infectious diseases. Already Pasteur was at work. An epidemic of chicken-cholera, in 1880, offered the opportunity for extended experiments. In the course of this work, a chance observation gave him the clue to vaccination with bacteria of attenuated virulence. It had been his routine practise in the experimental production of chicken cholera to use fresh 24-hour cultures; these always produced the disease readily. But in the course of the work it happened that an old culture which had been set aside for a few weeks and forgotten, was used, with the unexpected result that the inoculated hens, although ill for a while, promptly recovered, and what was more surprising, remained refractory to subsequent inoculation of fresh cultures, though the same cultures were virulent for untreated hens. This phenomenon, the attenuation of virulence due to artificial cultivation, Pasteur used as the basis of a treatment by vaccination, which had the immediate effect (1880) of reducing the mortality of chicken cholera to one per cent. and the more remote but far more important effect of stimulating the study of specific therapy. Incidentally it was the link between Lady Mary Wortley Montagu's preventive inoculation and Jenner's vaccination, on the one hand, and modern theories of the production of immunity on the other.

The next step was with anthrax, a disease of cattle. The attenuation of chicken cholera virus had been due to artificial cultivation, but about this time Toussaint, of the veterinary school of Toulouse, made some observations on the attenuation of anthrax bacilli under the influence of increased temperature (heating to 55° C. for ten minutes). His observations, however, were without constant results. Pasteur, who was familiar with Toussaint's work, took up the matter and after a thorough investigation found that anthrax bacilli cultivated at a temperature of 42° to 43° C., became attenuated, and this attenuation persisted on artificial cultivation (1881). The inoculation of such organisms did not cause anthrax, and when later virulent bacilli of anthrax were inoculated, the animals were found to be immune. This was the scientific basis of the celebrated public test at Melun. Sixty sheep and ten cows were placed at the disposal of Pasteur; twenty-five of the sheep and six of the cows were to be vaccinated with attenuated anthrax bacilli, and after an interval of twelve to fifteen days this was to be repeated. Later this lot, and also twenty-five untreated sheep and four untreated cows, were to be inoculated with a virulent culture of an-

thrax bacilli. Ten sheep were to have no treatment at all. "The twenty-five unvaccinated sheep will all perish," wrote Pasteur, "the twenty-five vaccinated ones will survive." This magnificent faith based on exact experimentation was justified. All happened as Pasteur predicted. For medicine a new era was at hand; Huxley, in 1880, estimated that the money value of the results of Pasteur's vaccination treatment was sufficient to cover the war indemnity paid by France to Germany in 1879. As the years go by and the influence of Pasteur widens the horizon of preventive medicine and the treatment of disease by immunizing methods, civilization's indebtedness to Pasteur is almost beyond the grasp of the imagination.

His discoveries in vaccination against swine erysipelas and hydrophobia are as fascinating, in their "mingling of experimental skill and scientific imagination" (Herter), as all that he did before. But while Pasteur is an engaging figure, worthy of much more than this simple lecture that we are devoting to him, yet he is not the whole story, and at this point we must turn away from him and proceed to another line of advance: one, however, which was in part the result of his genius and his indefatigable labor. This, the discovery of antitoxic sera, will be discussed in the next lecture, in connection with other modern problems and methods in medical research. But here let me remind you that it was Pasteur, afflicted at the age of 46 with a hemiplegic paralysis—which, by the way, left its traces during the remaining twenty-five years of his life—who said,

> Work can be made into a pleasure, and *alone* is profitable to a man, to his country, to the world.

It would be difficult to find in any field of human endeavor an individual whose life and labors exemplified this precept better than do the life and labors of Louis Pasteur.

LECTURE IV

Present-day Methods and Problems

The important activities in scientific medicine at ' may be said, without fear of contradiction, to be i' of (1) immunology,[1] (2) protozoology, (3) chem-

[1] The use of this term is not perhaps above critic[i] and need of some comprehensive word to cover the v

ological chemistry, (5) experimental pharmacology and (6) experimental pathology. The methods and problems of these various phases of medicine it is my intention to discuss, some at length, others briefly, in the present lecture.

Immunology is the science which would explain and apply the mechanisms by means of which the animal body is enabled to resist disease. As has been shown, the efforts of bacteriologists until about 1890 were devoted almost entirely to the study of the etiology of the infectious diseases and to attempts to combat these by vaccination with attenuated viruses. Another phase of bacteriology was, however, already under way, and this, in the earlier nineties, not only yielded results of great practical importance, but opened a new and ever-widening field of investigation. This was the study of the mode of action of invading bacteria and their products, that is, of the process of infection and intoxication, and the mechanism by which the host combats the invasion and aborts or cures such infection by overwhelming the foreign organism. One of the first results was the study of a group of soluble poisons, toxins—formed by certain bacteria and which it has been found are responsible not only for the symptoms which follow certain infections, but also for that effect on the cells of the host which stimulates the formation of the antibodies which we call antitoxins. Pasteur in his study of chicken-cholera had noticed that a bacteria-free filtrate of a culture of the specific microorganism of this disease could cause the symptoms produced by the bacilli themselves, but does not seem to have given much importance to the observation. Later (1888) two of his assistants, Roux and Yersin, found the same to be true of filtered cultures of the diphtheria bacillus. Later it was found that the tetanus bacillus and the bacillus (*B. botulismus*) of meat poisoning yielded similar soluble poisons.

Further study showed that the various bacterial toxins produce not only a fatal intoxication, but that each has its distinctive effect, as shown by symptoms or anatomical lesion, when injected into animals, thus demonstrating that the poison of each bacterium possessed a specific action. This led not only to a better understanding of the pathology of such diseases as diphtheria and tetanus, but eventually, and of far greater importance, to the discovery of curative and prophylactic

by the term "studies in immunity" and "serology," which in themselves are not adequate, are given as justification of its use.

sera, or as they are generally known, antitoxic sera. The first step in this direction was taken when Behring and Kitasato (1890) showed that animals could be immunized against weakened diphtheria toxin and that the serum of such animals is capable of protecting other animals against its intoxication, and, moreover, demonstrated that such a serum can be used to cure the toxic symptoms produced by the diphtheria bacillus. This curative power, furthermore, was found to be due not to an action on the bacteria, but to a neutralization of the toxin which the bacteria produced; also the serum was strictly specific, that is, the serum of an animal immunized against diphtheria toxin protects only against diphtheria; that prepared by the use of tetanus bacilli, only against tetanus. This led directly to the production by Behring and Knorr of diphtheria antitoxin for therapeutic purposes (1894) on a large scale and to a general awakening as to the possibilities of serum therapy. The great benefits of diphtheria antitoxin as a curative and prophylactic serum are known to all; since its general use, in 1896, a reduction of the death rate in diphtheria from 45 per cent. to 10 per cent. marks this therapeutic measure as one of the most brilliant discoveries of medicine and of the brilliant century in which this discovery occurred.

The success with diphtheria antitoxin aroused the hope that a general principle—that of the formation of antibodies for the toxins of all bacteria—had been established on the basis of which it would be possible to develop curative sera for all infections. This expectation—on account of the simple fact that most bacteria do not produce soluble poisons—has not been fulfilled; but the impetus which the principle of serumtherapy gave to investigation has led to activity of great and permanent value, and to the development of a new science, immunology or serology, as it is variously called, which attempts to establish laws for the conditions which determine natural resistance to infectious diseases and the factors which increase or diminish this resistance. I approach this subject with hesitation, for the many difficulties it offers can not readily be overcome in a short presentation such as this must be. A few brief statements, stripped of the less familiar terms may, however, serve to elucidate the main lines of investigation.

All immunological studies are based on the known fact of the reinforcement of natural resistance to disease, as illustrated by serum therapy in diphtheria and by vaccine therapy in anthrax. The at-

tempts to elucidate the principles underlying these two methods have led to the development of many fruitful hypotheses and theories, and many diagnostic and curative procedures of great value. It was early evident that the explanation of resistance to infection, either natural or acquired, must be sought in the cells or fluids of the body and especially of the blood. Metchnikoff (1884) was the first to show the importance of the white cells of the blood in combating infection through their power of engulfing and dissolving bacteria, and his pupils have supported his views, both as to the direct and indirect influence of these cells, the leucocytes, in the production of immunity. On the other hand, since Nuttall, in 1888, demonstrated the bactericidal power of the fluids of the body, and particularly of the blood serum, the relation of the body fluids to infection and immunity has been incessantly studied. As a result, schools have arisen, some supporting the cellular theory and others the humoral theory, and still others combining both theories in the attempt to reach an adequate explanation of the process of immunity. With these schools are associated most prominently the names of Metchnikoff, Ehrlich and Bordet.

One of the earliest and most important observations, after the discovery of antitoxins, was that of Pfeiffer (1894). This was the demonstration that a guinea-pig, into which has been injected the spirillum of cholera, develops in its body-fluids a substance capable of dissolving the cholera spirillum. This bacteriolytic substance is specific, that is, it destroys only the cholera spirillum; and Pfeiffer and his followers, pushing their investigations further, found that this principle of a specific lytic body could be applied to other bacteria and to foreign animal cells as well. Its development led to great advances in the theory of immunity, to the development of the fruitful hypothesis known by Ehrlich's name, and to the production of antibacterial sera, *e. g.*, antistreptococcus serum, as contrasted with antitoxic sera.

Likewise, it was discovered that the serum of animals receiving injections of a given bacterium had the power to agglutinate this organism; and moreover that this principle held good for the blood serum in certain diseases of man. Upon these observations was based (1896) the serum (Widal) reaction for typhoid fever, a definitely specific and reliable diagnostic method which has been followed by many other valuable tests based on the same principle and grouped under the general head of serum diagnosis.

At the same time older procedures were not forgotten, as is shown by Haffkine's extension of Pasteur's principle of vaccination to include protective vaccination against cholera (1893) and plague (1896) and more recently Wright's application of it to typhoid fever. Thus the last decade of the nineteenth century is marked by the birth of both serum-therapeutics and serum-diagnosis and by the extension of the idea of preventive inoculation. As may readily be seen, the fundamental observations of Pasteur, of Behring and of Pfeiffer had been elaborated into some of the most serviceable principles, acknowledged at the moment, in the science and practise of medicine. Nor is this influence a matter of the past. In our own day has been established the theory of specific precipitation of foreign proteins (Uhlenhuth, 1901). This has led to the elaboration of a specific test for the differentiation of both vegetable and animal proteins, a method which has been adopted for the determination of species, not only in bacteriology, but also as a medico-legal test for determining the origin of blood stains and as a general biological procedure.

So also, through the work of Denys and later of A. E. Wright, a body has been recognized in the serum which had the power to prepare bacteria for ingestion and digestion by the leucocyte. To this body the name of opsonin or tropin has been given. You will remember that Metchnikoff discovered the fact that the white cells of the blood have the power to engnlf bacteria, Wright supplemented this conception of demonstrating that a substance in the serum could so affect bacteria that they would be taken up more readily and in greater numbers; also he demonstrated that this opsonic power of the serum could be increased, and as the results of his teachings a definite opsonic therapy has developed. This treatment depends on the principle of vaccination with bacterial products. Before Wright, with the exception of Pasteur's treatment for hydrophobia, vaccination was used as a preventive measure only, but the studies which his observations have stimulated have led to very satisfactory results in the treatment of certain local infections as those due to the pus cocci and colon bacillus. Also, these studies have extended the practise of immunizing vaccination, as a prophylactic measure with, it has been claimed, most favorable results in the prevention of typhoid fever. For example the sanitary record of the maneuver division of the United States Army recently stationed on the Mexican border shows that in a body of 8,097 enlisted

men, careful sanitation and antityphoid inoculation prevented almost entirely the occurrence of typhoid fever; only one case of typhoid fever was observed, and it was not fatal; while at the same time in the near-by city of San Antonio 49 cases were reported. Comparing the record of the maneuver division with that of a division of the Seventh Army Corps stationed at Jacksonville, under quite similar circumstances in 1898, we have one case of typhoid among the 8,097 men of the former and 2,693 undoubted cases among the 10,759 men of the latter division. It must be admitted in regard to this record of the maneuver division, that it is difficult to say to what extent the excellent showing was due to careful sanitation and to what extent to the antityphoid inoculation, but past experience with troops in camp would indicate that inoculation was an important factor at San Antonio. The question of the value of preventive inoculation is, however, still an open one. So also are other applications of the principles of immunity, as the production of anti-sera for snake-venom, and for the irritant (and perhaps intoxicating) vegetable agent causing hay fever.

I have earlier in this lecture referred to methods of serum diagnosis depending on agglutination or solution of bacteria or on the precipitation of protein. Immunology has recently contributed to medicine another diagnostic method of great value. Its principle is that of complement fixation, the theory of which is too complicated for brief explanation, but the method as applied to syphilis, in the well-known Wassermann test, has since 1906 occupied a most prominent position in the diagnosis and treatment of this disease, and is now accepted as a method of great value in the more obscure cases, and numerous attempts are being made to apply the principle to other diseases.

Another phase of immunological study is that of anaphylaxis, a subject concerning which the professor of pathology in this university is one of the best known authorities. Anaphylaxis, the condition of increased susceptibility dependent on the sensitization of an organism to a foreign protein, is by no means thoroughly understood, but it has thrown light upon immunity from a new angle and has stimulated an enormous amount of investigation. Its utilization in the detection of specific proteins, its apparent explanation of the tuberculin, mallein and similar reactions, the light it has thrown on serum sickness, so-called, and the possibility it offers of explaining diseases characterized by critical phases, have attracted a host of investigators, who see in it the key to

many little understood phenomena of disease. As yet the practical results are meager, but the ultimate outcome promises much for medicine.

Another field, and one in which American investigations have been of the greatest importance, is the study of diseases the etiology of which is unknown, but which, it has been supposed, are in some instances due to filtrable or ultramicroscopic viruses. The recent work on poliomyelitis by Flexner and his associates is an example. This disease, appearing irregularly in sporadic and epidemic form, was in the past not definitely grouped among the infectious diseases. All attempts to find a causative microorganism have failed. The workers of the Rockefeller Institute and also certain European investigators have shown that the tissues of the central nervous system contain the virus, and that when the fluids of such tissues are injected into monkeys, typical poliomyelitis results. Moreover, the experimental evidence points to an elimination of the virus through the upper respiratory passages, thus offering a substantial basis for scientific prophylaxis through the proper care of the secretions of the nose and throat. Such investigations show how important the methods of immunology are, for here we have a disease which, as the result of the application of such methods, is definitely placed among the transmissible diseases and is given a satisfactory theory for prophylaxis in spite of an utter absence of knowledge concerning its causal agent. An analogy is seen in yellow fever, the microorganism causing which we do not know and for which we have no specific treatment, but which is controlled simply through our knowledge of its transmission by the mosquito.

While on the subject of Flexner and his work mention must be made of the most important contribution in recent years to our list of curative sera, the antimeningococcus serum. The production of this serum, which in the best form is the result of the labors of Flexner and his associates, is an accomplishment which, in reducing enormously the mortality of epidemic meningitis, is in itself a sufficient justification for the establishment of the Rockefeller Institute. The beneficial results of its use are very definite and the mode of its administration, by direct injection into the spinal canal, has been of great value in emphasizing the importance of the local treatment of localized infections.

Many other phases of activity in the field of immunity might be presented, but this brief and disconnected summary will, I hope, suffice to indicate something of actual accomplishment in this field, the main

lines of present endeavor, and the many opportunities for future achievement. Much of present-day effort may not lead immediately to tangible results—an outcome not uncommon in medical research—but the volume of work in progress and the vigor with which it is being prosecuted promises ultimately the solution of the many problems of the infectious diseases.

The Investigation of Cancer.—In no field of medical science has the modern experimental method given greater results in a few brief years and offered greater promise for the future than in the study of that fatal and obscure disease, cancer. Owing to the brilliant initiative of Jensen in Denmark and Leo Loeb in this country, it has been shown that a form of cancer occurs in certain lower animals, particularly in rats and mice, that can be artificially transmitted from one animal to another of the same species. This fact has afforded a means of studying in detail the method by which a malignant tumor grows in the body and more particularly has thrown light on the resistance or immunity to tumor growth which may occur naturally in certain individuals and which may even be artificially produced. Scattered over the world are small groups of individuals, more particularly in England, in Germany and in America, who are devoting their entire energies to the solution of this problem. From several divergent sources have come published results of experiments which offer the greatest promise that we may soon learn a method of curing these tumors. Already Ehrlich and Wassermann have shown the possibility of preparing specific cellular poisons for cancer analogous to those used in curing protozoan diseases. The final clue which will unravel the mystery of this complex disease would not appear to be as yet fully in hand, and yet I think no one of those most conversant with the problem would be surprised to find to-morrow that it has been discovered and that cancer was curable.

Protozoology.—It is of interest that about the year 1890, when bacteriologists ceased to announce discoveries with their accustomed regularity, owing to the fact that all readily recognized pathologenic bacteria had been discovered, the systematic study of protozoa began and some of the single-cell forms of life in the animal kingdom soon took a place as disease-producers alongside the corresponding form of the vegetable kingdom. Until this time, protozoa had been found in only two diseases of man, dysentery and malaria. In the year 1890 appeared the first books on the subject of protozoa as causes of disease, a small vol-

ume of one hundred pages by L. Pfeiffer, followed in the next year by Doflein's more extensive discussion of the same subject from the broader biological point of view. The bacteriologists of the preceding decade had by their efforts limited the number of diseases in which a bacterial etiology could be readily shown and it was natural, therefore, that the attention of investigators turned to the study of other microorganisms as factors in the production of disease. The careful technic of the bacteriologist had shown the methods to be used in the study of etiology, and, undoubtedly, the publications of Pfeiffer and Doflein stimulated general interest in the search for pathogenic protozoa. However this may be, it is a matter of record that in 1890 "only two human diseases were suspected of being caused by protozoa. . . . To-day more than fifteen are known or suspected to be of protozoan origin" (Calkins).

In the discussion of bacteriology I have referred to Leeuwenhoek as the first to see bacteria; he was likewise the first to see protozoa (1675). Two hundred years later, Bütschli (1875) offered conclusive evidence of the unicellular nature of these minute forms of animal life. In the intervening period, however, owing largely to the work of O. F. Muller (1786), Ehrenberg (1833–38) and Dujardin (1835–41), many forms had been removed from the "chaos animalculæ," the name under which Cuvier had classified them and their structure had been studied by Siebold (1845) and Max Schultze (1863). In this later period also several forms now familiar to us as occasional parasites of man had been described; as the *Trichomonas vaginalis* (Donné in 1837), the *Cercomonas hominis* (Davaine, 1857), the *Balantidium coli* (Malmsten, 1857) and the *Lamblia intestinalis* (Lambl, 1859).

The first parasitic protozoon, however, to be definitely associated with a specific disease of man was the ameba discovered by Lambl (1860), first observed in the human intestine by Lösch in 1875, and said by the latter to be the cause of amebic dysentery. In 1891 Councilman and Lafleur, after a very accurate study of this disease, as it occurred in Baltimore, came to the conclusion that two types of amebæ must be recognized; one, the *Ameba coli*, was harmless, another, which they called *Ameba dysenteriæ*, they claimed to be the cause of tropical dysentery. In this view they were supported later by the feeding experiments of Casagrandi and Barbagallo (1897) and of Schaudinn (1903); the latter also introduced the name *Entameba histolytica* for

the pathogenic form, and *Entameba coli* for the harmless form. It has since been found that two forms of tropical dysentery exist, one of which, as shown by Shiga, Kruse and Flexner, is due to bacteria—but equally definitely has the etiology of an amebic form been established.

In the meantime another protozoan disease was being investigated. Laveran, a French military physician, stationed in Algiers, announced in 1880 that the dancing pigmented bodies frequently seen in the red blood cells in malaria were altered hemoglobin granules within a protozoon to which he gave the name *Oscillaria malariæ*. This name was altered by Marchiafava and Celli to *Plasmodium malariæ*, in 1885, and Golgi, in 1886, by demonstrating that the characteristic paroxysms of the disease coincide with the segmentation or sporulation of this parasite, settled definitely the question of its etiologic relation to malaria.

The work on malaria constituted a very large part of the activity in medical investigation at this time. Until the middle of the nineties, many investigators were interesting themselves in the study of the different forms of parasites concerned, their life history and the methods for demonstrating them; these activities, with the study of similar parasites in birds, gave a great impetus to the study of pathogenic protozoa, and prepared many workers for a wider field.

Nevertheless, but few were prepared for the wonderful announcement by Smith and Kilbourne, in 1893, of the transmission of a protozoan disease through a blood-sucking insect. In this, the work of our own countrymen, on a malaria-like disease of cattle, Texas fever, the tick was shown to be the carrier of the *Pirosplasma bigeminum*, the organism responsible for the disease. The importance of this observation can not be over-estimated. It was the finger-post indicating the way to progress in the study of the transmission, and therefore of the prevention, of protozoan disease, and to Smith and Kilbourne belongs the credit of this great advance, which, it must be admitted, had a great influence on the study of the transmission of malaria and yellow fever. Many suggestions had been made from time to time that these diseases might be due to transmission by the mosquito; and these theories became indisputable fact when Ross announced from India in 1897–99 that the malaria of birds was transmitted by a species of mosquito (*Culex*) and when Grassi, Bignami and Bastianelli (1898–99) likewise demonstrated that malaria of man is transmitted by another species of mosquito (*Anopheles*). But before this, Bruce's study (1894–97) of

the Gulf ports, an increase in human comfort and happiness and an increase in national prosperity and national progress; but still more, to them, as also to Ricketts, who investigated Mexican typhus and succumbed to it, and to Walter Myers and Everett Dutton, of the Liverpool School, our science owes much in methods and in ideals.

Truly, no field of medicine offers so much of tragedy, of romance and of spectacular discovery as that of the pathogenic protozoa, and few offer such great difficulties. It is, however, one of the most promising fields of present-day effort and one which I would like to present more in detail. It must, however, suffice to end this presentation with mere mention of the successful cultivation of amebæ (Mesnil and Mouton), the cultivation of the trypanosomes (Novy and MacNeal), the discovery by Schaudinn and Hoffman of the spirochete, which we now know to be the cause of syphilis, and the finding of a very similar organism in yaws. Time might also be given to the various trypanosomes, to the spirochetes causing diseases of cattle and poultry and to the Negri bodies of rabies; also the discussion might be extended to include the broader field of tropical medicine, but instead, as it is the direct outcome of the study of protozoa, I must turn to a new phase of research in medicine, that known as chemotherapy.

Chemotherapy

As the study of protozoan diseases progressed it soon became evident that the method of combating such diseases must be different from that used against diseases due to bacteria. The chronicity of amebic dysentery and relapses in malaria indicated that the protozoan diseases are not self-limited and therefore not characterized by the development of immune bodies, similar to those of the acute bacterial diseases; also artificial cultivation failed to demonstrate that protozoa yielded bodies analogous to bacterial toxins, capable of producing, on injection, bodies with efficient antitoxic power. These and other facts precluded, therefore, a therapy based on the principles applied to bacterial vaccines or antitoxins.

The beneficial effect of quinine in the treatment of malaria and the cellucidal action of quinine on the ameba and other protozoan forms indicated that a therapy, to be successful, must be one in which a substance toxic for the protozoa in question is brought into direct contact with it. The establishment of such therapy and incidentally the crea-

tion of a new science, that of specific chemical therapeutics, has been the work, in the past seven years of Professor Ehrlich, of the Royal Prussian Institution for Experimental Therapeutics at Frankfurt. This new therapy is based on the principle that "a specific chemical affinity exists between specific living cells and specific chemical substances." This principle has always been the main theme of Ehrlich's work, as is seen in his application of the aniline dyes to the study of the cells of the blood, his studies on vital staining and the selective action of methylene blue on the nervous system, the use of methylene blue in the study of the oxidations and reductions occurring in tissues, and his extensive studies in immunity. This experience, covering a period of twenty-five years, led Ehrlich to the belief that "for each specific parasite a specific curative drug must and could be found." And upon this assumption he began his experiments.

To appreciate thoroughly the difficulties of this task and the magnitude of the results, it must be understood that Ehrlich proposed a sterilization of the body in so far as the microorganism, against which the specific remedy was aimed, was concerned. The destruction of bacteria or protozoa outside the body by chemical means is a commonplace of surgical and public health measures; but the destruction of living microorganisms within the living body had never, until Ehrlich accomplished it, been possible without, at the same time, destroying also, in part or in *toto,* the cells of the host. To avoid the latter it was necessary, therefore, that the protozoa-destroying substance should have a specific chemical affinity for the protozoa in question, but little or no chemical affinity for the cells of the host.

It is impossible to give the details of Ehrlich's seven years of work on this problem; a brief description of the main results must suffice. The first work was done with trypanosomes, the mouse, which could be readily infected, being used as an experimental animal. After testing, with the aid of his assistant, K. Shiga, many hundreds of dye-stuffs, some old and some new, one, a member of the benzidin group, was found which retarded the progress of the trypanosome infection for several days. This led to a limitation of the experimentation to a study of the synthetic products of the benzidin group, many of which were made for the first time by Ehrlich and his assistants. The result was the discovery of a substance which exerted an actual curative effect upon trypanosomiasis. This substance, a red dye destroying trypano-

somes, was given the name trypan red (trypan roth). If twenty-four hours after mice had been infected with the trypanosome of *Mal de Caderas,* a single injection of this dye was made, animals which ordinarily died in four to five days went on to permanent recovery. The blood, twenty-four hours after injection, was found to be free of trypanosomes, which indicated that the effect of the injection was to destroy absolutely every infecting protozoan. Thus was demonstrated for the first time the possibility of completely sterilizing the animal body by a chemical disinfectant without injury to the cells of the host.

In the course of this work an interesting observation was made. If, instead of a dose necessary to destroy all the trypanosomes, a slightly smaller dose was injected, the trypanosomes would disappear from the circulation for a short time and later reappear. If such injection was repeated at intervals, the period of disappearance of the trypanosome would gradually shorten until finally the drug would have no effect on the infecting organism; in other words, a strain of trypanosomes had been developed which were resistant, immunized as it were, to trypan red and this resistance could be transmitted through many generations. Also, it was found that trypan red was a curative agent only for the infection in mice; on the trypanosome diseases of larger animals, as horses and cattle, it had no curative effect. However, the experience with trypan-red pointed the way to a solution of the difficulty; either a drug must be found which by a single injection would kill every parasite, or several different drugs must be used, which, acting on the same parasite, and thus allowing a combination treatment, would lead to a cure without the danger, to the host, of a single massive dose. It is impossible in the scope of these lectures to follow in detail Ehrlich's work or to go into the complicated chemistry of the substances used. It must suffice to say that as the work went on, Ehrlich and Weinberg found a substitution produced of trypan-red, amidotrypan-red, which destroyed the virulent parasite of nagana, the tse-tse fly disease, and that Mesnil and Nicolle, using the blue and violet azo-dyestuffs, prepared a trypan blue and trypan violet which caused the disappearance of the parasites of nagana, surra and mal de Caderas.

Another line of progress was through various combinations of anilin with arsenic. Before Ehrlich entered this field, Bruce had found arsenic to be a drug of value in treating the trypanosomiasis of horses (surra) and Thomas had found that atoxyl, a combination of arsenic

and anilin, would cure a large percentage of infected animals. This latter substance had also been used in the treatment of the human disease, sleeping sickness. Ehrlich made a thorough study of arsenic compounds, and the result was the combination, arsenophenylglycin, a single dose of which absolutely and permanently cures all animals suffering from trypanosome infection.

At about this stage of the development of chemotherapy, Uhlenhuth and Salmon published an account of the brilliant use of atoxyl in the treatment of syphilis, which as we have mentioned, is due to a protozoan, the spirocheta pallida. Unfortunately, as atoxyl sometimes caused blindness, its use was not without danger and therefore not desirable. So Ehrlich immediately turned his attention to the protozoan diseases caused by spirilla, as chicken spirillosis, relapsing fever and syphilis. His labors on these diseases constitute one of the most fascinating of modern laboratory studies and his results are among the greatest of scientific discoveries. His intimate knowledge of the constitution of atoxyl and other arsenic preparations allowed him to proceed rapidly with "a great variety of substitutions, and innumerable arsenic derivatives were synthetized." As human syphilis could be transmitted to the rabbit and relapsing fever to the mouse, the power of these preparations, as soon as manufactured, could be tested in the laboratory. The object, of course, was to find a substance which would kill the spirochetes without injury to the host. The result was the justly celebrated Ehrlich-Hata 606, chemically known as dioxydiamidoarsenobenzol, sometimes shortened to arsenobenzol, and, more recently, receiving the commercial name, Salvarsan. This substance in a single dose, 58 times smaller than the *dosis tolerata* (the largest dose which could be given with safety), cured definitely chicken spirillosis; a single small dose destroyed the spirolla of relapsing fever in infected mice, and a single injection of one seventh the *dosis tolerata,* caused the spirochete of syphilis to disappear completely from the experimental lesions of the rabbit within twenty-four hours. This last experience naturally aroused the hope of curing syphilis in man by a single injection given in the early stages. Such treatment, if successful, would supersede, or at least supplement, the empirical treatment by mercury which required a course of several years' treatment before a cure could be assured. The toxicity of the substance was, therefore, tested on dogs and then, to make sure it had no ill effects, on healthy men (assistants

of Professor Alt), who volunteered for the purpose and finally the therapeutic effect was tried on relapsing fever in man. Iversen, of Russia, to whom this work was entrusted, found that one injection completely cured relapsing fever in 90 per cent. of his patients. Finally the substance was used in the treatment of syphilis in man. The completeness and rapidity of the curative action have been astounding. The effect on the lesions of the primary and secondary stages is to cause them to heal or disappear promptly; the spirochetes can not be found after a few days and the effect is apparently one of complete sterilization. Thousands of reports in the medical press confirm the general beneficial effect of this remedy and testify to the absence of ill-effects when properly administered. Even though further experience may modify the present optimism, nothing can detract from the magnificent service by which Ehrlich and his pupils have benefited humanity and added to the glory of medical science by establishing the principle of specific chemotherapy. With a record of about a dozen drugs[2] which can be used to cure or modify diseases caused by nearly a dozen different protozoa,[3] chemotherapy offers promise of results which, with serumtherapy and vaccination in bacterial diseases, will sharply limit the ravages of the transmissible diseases of man and animals.

Here we must leave the story of the infectious diseases, which has occupied our attention from the beginning of the third lecture to this point, and turn to a brief discussion of other methods of modern research in medicine, those of physiological chemistry, pharmacology and experimental pathology, which had their beginnings in the subjects (chemistry, physiology and pathology) discussed in the second lecture. The presentation must, however, necessarily be but brief and fragmentary, a mere summary, in fact, of aims and methods.

Physiological Chemistry.—The beginnings in this most important field of research were in Liebig's exact methods[4] for the study of organic

[2] (I.) The arsenic group: arsenious acid, atoxyl, acetylatoxyl, arsenophenylglycin and dioxydiamidoarsenobenzol. (II.) Azo-dyestuffs: trypan-red, trypan-blue and trypan-violet. (III.) Basic triphenylmethan dyestuffs: parafuchsin, methyl-violet and pyronin.

[3] Nagana, surra, sleeping sickness, mal de Caderas, Texas fever, chicken spirillosis, relapsing fever and syphilis.

[4] These appeared in the following publications: "Instructions for the Chemical Analysis of Organic Bodies," 1837; "Chemistry in its Application to Agriculture and Physiology," 1840; "Animal Chemistry or Organic Chemistry in its Application to Physiology and Pathology," 1842; "Handbook of Organic Analysis," 1853. (Dates taken from early English translations.)

chemistry and Wöhler's studies which are famous on account of his synthesis of urea. It is usually stated that the cultivation of physiological chemistry as a distinct science, with independent institutes of its own, dates from the eighth decade of the past century, when Hoppe-Seyler in 1872 established his laboratory at Strassburg and in 1877 founded the *Zeitschrift f. physiologische Chemie*. But although this period does represent the first attempt to sharply separate laboratories of physiological chemistry from those of organic chemistry, on the one hand, and of physiology, on the other, the first independent chair of physiological chemistry was established as my colleague, Dr. John Marshall, informs[6] me, at the University of Tübingen in 1845 and was held by Eugen Schlossberger; likewise Schlossberger's laboratory was the first one to be devoted exclusively to the study of physiological chemistry. It was to this chair that Hoppe-Seyler was appointed in 1861, and which he held until shortly after the close of the Franco-Prussian war, when he accepted a similar chair in the University of Strassburg.

Before and for some time after these events a great volume of work in physiological chemistry was done in laboratories of organic chemistry and of physiology; but the events at Tübingen and Strassburg served to concentrate attention on physiological chemistry and eventually to hasten the establishment of independent laboratories. For the first few years progress was slow; in 1882, to quote Dr. Marshall again, only two such independent laboratories, those of Tübingen and Strassburg, existed in Germany. In the intervening thirty years the situation has changed. Now, such laboratories exist wherever adequate teaching or intelligent research in medicine is attempted.

[6] Dr. Marshall's notes on the development of physiological chemistry at Tübingen are as follows: "In 1816 Dr. Med. George K. Ludwig Sigwart at the request of the Medical faculty of the University of Tübingen delivered from time to time lectures on 'Zoochemie,' but notwithstanding that he was made professor extraordinarius in 1818 he was not provided with a laboratory. In 1835 the professor was given the use of quarters in the laboratory for agricultural and technical chemistry which was located in the old Tübingen castle. In 1845 Eugen Schlossberger, a pupil of Liebig and of Heinrich Rose was called to a professorship of physiological chemistry in Tübingen which was the first independent chair of physiological chemistry created at a German university and the laboratory was the first one to be established as a separate institution. From 1861 until 1872 this chair was held by Hoppe-Seyler when in 1872 he resigned to accept a professorship of the same title in the newly revived university at Strassburg. The laboratory in the old castle was occupied until 1885 when it was removed to the new building which had been erected for the subject."

The early physiological chemistry was quite different from that with which we are familiar to-day. It was largely the analysis of the chemical composition of various body tissues and fluids. This early conception, however, soon gave way to a dynamic conception, the idea of function, and present-day investigators in physiological chemistry are concerned chiefly with the ways and means of cell action. The chemical constitution of the cell, its enzymes, the methods by which it builds up complex bodies from simple substances, or disintegrates a compound to its simplest constituents; in brief, the problems of digestion, metabolism and secretion in health and disease. These are the problems which concern this science and which, as its methods have been extended to include the study of the vegetable kingdom, as well as the lower forms of animal life, is now more frequently known by the broader term, biological chemistry. The dynamic point of view which to-day characterizes physiological chemistry is largely due to two influences which have come from the outside: (1) The study of intramolecular structure as carried out on the sugars, purins and proteins by the Fischer school, and (2) the study of the nature of chemical reactions, as taught by the modern school of physical chemistry, led by van't Hoff.

Its fundamental problems which during recent years have engaged the attention of its best workers and which still hold their attention are (1) the chemical composition of the protein molecule, (2) the part played by ferments or enzymes in the metabolic changes which occur within the cell and which are responsible for the functions of the various organs and tissues, (3) the general problems of nutrition and the relative values of different food-stuffs, (4) the question of the interrelation of function, that is, of the influence of the secretion of the cells of one organ or tissue on the cells of a remote organ or tissue, (5) the mechanism, from a chemical point of view, of natural and acquired resistance to disease and of phenomena associated with such resistance.

All of these investigations, it is seen, have for their object a better knowledge of the mechanism of cell activity.

Experimental Pharmacology or pharmaco-dynamics, as it is sometimes called, applies the methods of physiology and chemistry to the study of the action of drugs, poisons and other substances which may alter normal function. Its early development corresponds to the period of the application of exact experimental methods to physiology which, as has been shown in an earlier lecture, dates from about 1840. Buch-

heim, professor of materia medica at Dorpat, established in his own house, in 1849, a laboratory for the study of pharmacological problems; somewhat later this laboratory became a part of the University of Dorpat and was, therefore, the first laboratory to procure for pharmacology, recognition as a science of university rank. Furthermore, Buchheim in 1876 in the *Archiv f. experimentelle Pathologie und Pharmakologie* (founded in 1873) defined the methods and aims which have guided pharmacological work for the past thirty-five years. He also made the first classification of drugs according to their physiological action.

The proper study of pharmacology is all-embracing. It includes not only the study of the mode of action of remedial agents in healthy individuals and the influence on such action of various abnormal or pathological conditions, but, also, the effect of a great variety of substances, as bacterial toxins, the secretions of venomous serpents and the products of metabolism, in short, all animal, vegetable or mineral substances in any way capable of altering normal physiology. Moreover, the study of the effect of these various substances is not limited to man and the higher animals, but includes the use of the lower invertebrate forms, bacteria and protozoa. It is, therefore, an all-inclusive branch of biology, dealing with the "comparative study of the action of chemical bodies on invertebrate and vertebrate animals." Its achievements are of interest to physiology, to which science it has contributed much, both in method and in fact; to chemistry, in that pharmacology has added largely to the data concerning the interaction of cell and chemical substance; and to practical therapeutics, in that it presents new remedies, explains the action of old remedies and defines the limitations of drug-therapy. Finally it has a definite relation to the general public welfare in that, by its methods, it establishes procedures for determining the potency of therapeutic remedies, thus preventing, on the one hand, ill effect from a drug of unusual power, and, on the other, guaranteeing a remedial agent of standard strength.

Experimental Pathology and Pathological Physiology are branches of pathology and physiology which, combining the methods of both these sciences with those of chemistry, attempt, by the study of abnormal conditions experimentally produced, to explain the disturbance in function consequent upon cell or tissue injury or disturbances in physiological or chemical equilibrium. Combining as they do the methods of several of the medical sciences, and having for their object the elucida-

tion of definite problems in clinical medicine, they are essentially the methods of a science of clinical medicine and have aided materially in the advance of this branch of medicine.

Such are the methods and problems of present-day research in medicine. The history of medicine teaches us that new methods and fruitful hypotheses may be brought forth at any time; new diseases, on the other hand, can now be expected only through changes in social relations and practises or as the result of new industries. Advance, therefore, would appear to lie in the concentrated application of present methods to present problems and in the application of such new methods, as may be confidently expected to appear from time to time, in any science which is so actively cultivated as is the science of modern medicine.

In this narrative of research medicine I have grouped the various phases of my presentation about men or events. These, as Hippocrates and Galen in antiquity; Vesalius and his influence on anatomy; Paré and his observations in surgery; Harvey, Hunter and Haller and their more or less isolated discoveries in physiology; Morgagni and his observations in pathological anatomy; and Jenner and his discovery of vaccination, represent the epoch-making efforts of workers widely separated and more or less isolated. In the early part of the nineteenth century, Johannes Müller, Liebig and Rokitansky founded respectively the sciences of physiology, organic chemistry and pathological anatomy upon the basis of concentrated laboratory effort and gave to these sciences an impetus the result of which we recognize to-day in the importance which they have attained. The main line of advance, however, has been in the past 70 years, and was made possible by the study of cells, through (1) the work of Schleiden on vegetable cells and of Schwann on animal cells thus establishing the cell doctrine; (2) the application of this theory by Virchow to pathology, and (3) Pasteur's conception of the rôle played by microscopic cells in fermentation and his application of this to the etiology of disease. Out of Pasteur's work grew the treatment of bacterial diseases by vaccines and antitoxic sera, and the increased knowledge of infectious diseases gained by the study of bacteriology, led to the search for protozoa as causes of disease and the demonstration of the etiological importance of the latter, led, in turn, to the development of Ehrlich's chemotherapy as a means of com-

bating protozoan disease. But while this was the main line of advance we have seen how Pasteur influenced surgery through Lister, and how anesthesia, through the efforts of Morton came also to aid this science. So, likewise, physiological chemistry came into being, indirectly as a result of Liebig's work, but more directly as a result of the needs of physiology for a better understanding of cell composition and enzyme action, and, finally, both physiology and physiological chemistry contributed to the establishment of pharmacology and experimental pathology. Medicine, in the sense of internal medicine, benefited by each and every advance in each and every one of its contributory branches, and, through the application of the principles of physics and chemistry to methods of diagnosis, gained its present large equipment of instruments of precision and means of exact interpretation; surgery in like manner gained the X-ray and many technical and mechanical procedures; and preventive medicine, utilizing the knowledge obtained through bacteriology, protozoology, immunity and chemistry, shares, with the science of engineering, the glory of promoting in greater degree than all other factors the social and industrial welfare of humanity.

The facilities and opportunities possessed by American universities for the continuance of this progress will be the subject of the fifth lecture.

LECTURE V

MEDICAL RESEARCH IN AMERICAN UNIVERSITIES; PRESENT FACILITIES, NEEDS AND OPPORTUNITIES

IF the preceding lectures have a special value, it is in indicating, on the basis of past experience, the methods and mode of approach, which will presumably yield the greatest measure of success in the investigation of present and future problems. Looked at in this light what I have cited of the past shows four important aspects:

1. The epoch-marking labors of isolated individuals working independently.

2. The application of the exact methods of physics, chemistry and biology to medicine.

3. The development of laboratories for the organized and intensive investigation of the various problems of medicine.

4. The idea of diminishing suffering and ameliorating social conditions.

The first of these factors naturally suggests the names of Vesalius, Paré, Harvey, Hunter, Jenner, Morgagni and Haller. Some of these may have been influenced by antecedent work as Vesalius by Herophilus and Erasistratus; Harvey by his forerunners, who studied the circulation of the blood; and all, perhaps, by the old teachings of Hippocrates or the experimental side of Galen's work, but the actual achievement of each, whether the result of chance suggestion, original conception, or keen observation, was the fruit of labors unassisted, prosecuted with difficulty, and in most instances in opposition to the traditions of the profession. Such independent effort, though most prominent in the period previous to the year 1800, always has had and always will have a place in medicine. This is seen in the efforts of the individual, even after medicine was influenced by its ancillary sciences and, indeed, in the days of organized laboratory effort. In this connection, one recalls Sir George Baker's demonstration that a form of colic, epidemic in character, occurring in Devonshire, England, was to be explained as a poisoning by lead; Captain Cook's conquest of scurvy; Auenbrugger's invention of the method of percussion; Laennec's invention of the stethoscope; the theory announced independently by Holmes and by Semmelweis of the transmission of puerperal fever and many other independent efforts in the practise of surgery and medicine, as those with which we associate the names of Pinel, McDowell, O'Dwyer and Trudeau.

Modern effort in research in medicine, however, as in science generally, is, it must be admitted, organized laboratory effort, and upon this type of effort present-day progress would seem to depend. Nevertheless, the individual is as important as ever, for "it goes without saying that laboratory buildings alone, even when adequately equipped and with a liberal maintenance budget, are far less important than the men who work in them" (Barker), but the laboratory now offers to the individual, with original conceptions or special talents, advantages, facilities and opportunities which, by aiding and supplementing the work of the individual, render isolated effort unnecessary, time-consuming and often futile.

Under the second head, the influence of physics, chemistry and biology, fall such men as the English physicists and chemists and the

French academicians—Boyle, Cavendish, Priestley, Galvani, Faraday, Tyndall, Lavoisier, Gay-Lussac and Berzelius. A more direct influence is seen in the entrance of Pasteur, a chemist, into the field of etiology; of Ehrlich, a physician, but chemically trained, into the field of immunity and specific chemical affinities; and of Metchnikoff, applying the methods of the biologist to the problems of pathology. Likewise Liebig and Wöhler and organic chemistry; Hoppe-Seyler and physiological chemistry; Arrhenius and physical chemistry, Darwinism, Mendelism, all have had their influence, and the methods and views they represent have been taken over by medicine and applied to the solution of its problems.

The influence of physics and chemistry in establishing the third factor—organized laboratory effort in special fields of medicine—we have seen in the beginnings of laboratory research in the second quarter of the past century. Virchow at the time he was urging the establishment of pathological laboratories epitomized the history of organization in medical effort as follows:

> As in the seventeenth century anatomical theaters, in the eighteenth, clinics, in the first part of the nineteenth, physiological institutes, so now the time has come to call into existence pathological institutes and to make them as accessible as possible to all.

Since then, the laboratory idea has spread rapidly; not alone laboratories of pathology have been founded, but also laboratories of bacteriology, hygiene, physiological chemistry, pharmacology and every branch of endeavor promising advance in the science of medicine. Not only have such laboratories come into existence in university schools of medicine and in hospitals, but many independent laboratories for research alone have been founded in the large medical centers, as the Pasteur Institute in Paris (1888), the Imperial Institute for Experimental Medicine in St. Petersburg (1890), the Institute for Infectious Diseases in Berlin (1891), the Lister Institute for Preventive Medicine in London (1891), the Institute for Experimental Therapeutics in Frankfort (1896), the Rockefeller Institute for Medical Research in New York (1901), the Memorial Institute for Infectious Diseases in Chicago (1902), the Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis in Philadelphia (1903). Likewise, municipal, state, provincial and national laboratories, devoted to work concerned with the public health, have been established. Some, follow-

ing the example of the first laboratory of hygiene, that of Pettenkoffer, founded by the Bavarian government in 1872, have been most active in investigation; others are devoted mainly to the routine work necessary for the conservation of the public health. How essential laboratories of the latter type are is shown by the fact that several states, New York among the first, have established county or district laboratories to care for the problems of communities distant from the state laboratory and the laboratories of the larger cities.

So also laboratories as an integral part of hospitals, the so-called clinical laboratories—the first of which was established by Ziemssen in Munich about 1886—have become a necessary part of every hospital which makes any pretense of accurate diagnosis and adequate therapy. The list might be extended to include also laboratories devoted to special diseases, as cancer and tuberculosis, diseases peculiar to the tropics, and diseases of animals, or to special branches as surgical pathology, neuropathology and psychopathy. This wonderful extension of the laboratory idea in medicine dates only from the simple beginnings of Purkinjé and Liebig in 1824–25. At the present day, Germany alone is said to have over two hundred such medical institutes, and to this policy of establishing laboratories must be ascribed her leadership in the medical sciences since the third decade of the past century.

From this brief recapitulation of the important influences affecting research in medicine, only one conclusion is deducible; that although the individual will continue to be the most significant factor in the situation, it is unquestionable that his perception will be constantly stimulated, his imagination quickened and his hands aided, by the opportunities, ideals and facilities of the laboratory. In the laboratory only can "the prepared mind" of Pasteur's adage ("In the fields of observation chance favors only the prepared mind") be properly fostered. It is in the laboratory, and under this term I include the properly conducted hospital as the laboratory of clinical medicine, that medicine keeps in close touch with new discoveries in physics, chemistry and biology, the second of the three important factors we have discussed. The situation in regard to the auxiliary sciences has not changed since the time of Liebig, Müller and Virchow. The investigator in the laboratory and the investigator in the hospital still look to these sciences for assistance and eagerly apply the discoveries in each of these to his own problems. The result is a decided advantage to medicine, not

only in that this revivifying and suggestive influence leads to accelerated progress in the science and art of medicine, but also in that it directly influences the health and therefore the welfare, commercial and social, of the community.

This brings us to the fourth factor which has influenced medical research in the past and should—indeed must—continue to be an ever-increasing influence in the future—the desire to ameliorate social conditions, by diminishing the causes of physical and mental ills. This, in a word, is the desire for social service; the impulse which actuated all of Pasteur's work, and which he himself expressed as the desire to contribute "in some manner to the progress and welfare of humanity." It is not sufficient that the individual as an investigator should be actuated only by his ambition and his investigations, or alone by his desire for exact abstract knowledge. If medical research is to be a vitalizing, reforming, uplifting factor, not only for the practise of medicine, but for the good of the community at large, then the whole man must be interested, heart and soul, not only in the technical and abstract results of his problems, but in their practical applications to medical and social conditions. What does this mean for medical research? That the laboratory shall be not only the brains, but the hands, of the community! It must recognize not only the problems of the community, but, solving the technical aspects of these problems, must demonstrate how they are to be met and cared for. In short, the investigator in medicine must be stirred by not only an abstract interest in human ills, but a direct interest in the problems, prophylactic or therapeutic, hygienic or social, of the community, with all its differentiation into industrial, commercial and domestic activities, of which he is a member.

If I am right concerning the importance of these various influences it would appear safe to conclude that progress in medicine may be expected in the future, as in the past fifty years, through the opportunities afforded the well-trained individual in well-equipped and well-organized laboratories, through the cultivation of the methods of auxiliary sciences and through the ideal of social service. And here I may say that in using the term "laboratory" I do not limit the term to the ordinary sense, but include the idea of research work in the hospital. One of the great influences of the application of the laboratory idea to medicine has been the recognition of the principle that hospitals should

be utilized not only for the care of the sick, which is the first and most important function of a hospital, but for purposes of teaching and investigation as well. With such a conception, a hospital becomes the laboratory of the science of clinical medicine and in it the clinician as an investigator studies disease by the same exact methods as are utilized in any other laboratory.

If, then, the laboratory and the hospital are the tangible means of progress in medicine which our universities offer, how may research in the university be best served and what advantage does the university gain by fostering research?

By limiting the scope of this discussion to the university I do not wish it to be thought that I desire to minimize the importance of the work done by independent institutions for research or by state and city laboratories. The important work done by the Rockefeller Institute for Medical Research, for example, has placed this institution in one group with the Pasteur Institute, Koch's Institute in Berlin, Ehrlich's Institute in Frankfort and the Imperial Institute for Experimental Medicine in St. Petersburg. The character of its present staff, including as it does, your former professor of physiology, promises as great work for the future as has been accomplished in the past. Likewise, the Memorial Institute for Infectious Diseases in Chicago and the Henry Phipps Institute of Philadelphia are doing valuable work in the study of the diseases for the investigation of which they were founded. Such institutions point the lesson of the economic importance of research, which, if fully grasped by the public, would guarantee the support of independent institutions in every large center or wherever special facilities for the study of particular diseases could be found. Moreover, all these institutions have recognized the necessity of an intimate connection with a hospital in order to render their investigations most effective.

So also laboratories of state or city departments of health as of the state of Massachusetts and the state and city of New York and the Hygienic Laboratory of the Public Health and Marine Hospital Service, supported by the national government, have made original investigation of the infectious diseases an important and often major part of their work. In addition the Hygienic Laboratory has made most important investigations in pharmacology. Other non-university research institutions, as the New York State Laboratory for the investigation of cancer, the Rockefeller Commission for the Study of Hook-worm Dis-

ease, Trudeau's laboratory at Saranac for the study of tuberculosis and that for the study of problems of nutrition supported by the Carnegie Institution at Boston, are of great importance. Such institutions, and I have not exhausted the list, devoted to the investigation of the problems of medicine and without affiliation with teaching institutions must be counted as among the most important factors in our social system.

Research in the medical school or the hospital, on the other hand, has developed slowly and has been in most institutions a matter of secondary importance. The reason for this is not difficult of demonstration when one remembers that even schools of university rank emerged only a short time ago from the proprietary state and that most physicians just past middle age can remember the two- and three-year course. Large classes, the belief in the didactic lectures, and the expense of laboratory equipment retarded the development of proper laboratory facilities and therefore the development of men trained to exact methods in the medical sciences. Likewise in the clinic the ideal teacher, with a few notable exceptions, was the busy consultant who devoted only a few hours of oratorical effort to clinical instruction and who disdained investigation as beneath the notice of a practical physician—an ideal which still holds in many of the more conservative schools and is responsible for the slow progress in the development of a science of clinical medicine. This type, however, is rapidly passing away and another generation may look back upon it as we do upon the age of the proprietary school, the two years' course and the amphitheater lecture.

It is not my intention to trace the beginnings of research in medical laboratories in this country, or, fascinating as it would be, if time allowed, to analyze early conditions and influences. A few men, however, stand out prominently, as, for example, Leidy, of Pennsylvania, teacher of anatomy and investigator in comparative anatomy, one of the greatest of American investigators in general biology, and Bowditch, who offered at Harvard in the seventies the first opportunity for organized research in physiology in this country. Laboratories of anatomy, that is, dissecting rooms, had always existed, but the modern type of anatomical investigation in anatomy is due to the influence of Minot, of Harvard, and Mall, of Hopkins. Likewise, laboratories of inorganic chemistry and so-called medical chemistry existed, but research in physiological and biological chemistry goes back only to Chittenden, of

Yale, and Macallum, of Toronto; Delafield, Welch and Prudden in New York and Fitz in Boston appear to have been among the first to control university laboratories of pathology in which at least a few men gave much of their time to teaching or investigation, but the great impetus to research in pathology and bacteriology coincides with Welch's affiliation with the Johns Hopkins Hospital, and experimental pathology as a sustained effort was first broadly cultivated by Flexner. Investigation in pharmacology by modern exact methods, in laboratories devoted to that subject, is the result of the labors of Wood at Pennsylvania, of Cushny at Ann Arbor, of Abel at Baltimore, of Herter in New York and of Sollman in Cleveland. The first university institute of hygiene was that established at Pennsylvania in 1892. These are the names which the compiler of American medical history one hundred years from now will compare, in discussing the development of our laboratories, with those of the period of 1820 to 1860 in Germany. Why? Because these men established not merely teaching laboratories, but stimulated investigation, inculcated exact methods and trained men, and thus made an impression upon the medicine of their time. This is true not merely of their influence in furthering research, but of their influence in advancing the fundamental principles of proper medical education. As soon as it was demonstrated that laboratories were indispensable to proper medical education, the day of the medical school worthy of university rank arrived and the proprietary medical school as an important factor in medical education became a thing of the past. Moreover, as I have intimated, the principle of laboratory instruction and laboratory research which gave to laboratory effort the strongest place in the curriculum has had a distinct effect on the clinical teaching of medicine and surgery, so that in some of our better schools the individual student now has that opportunity for immediate contact with the patient which allows the direct exercise of his powers of observation, of the use of instruments of precision and of exact procedures which assure the acquirement not only of knowledge, but power to obtain knowledge. The result is the recognition of the clinic as a place for the exercise of exact methods in the teaching of the clinical branches and in the investigation of disease. Both fields of activity, the hospital and the laboratory, now have the "common purpose to advance medical knowledge and thereby bring healing to the nations."

With this conception of a common purpose guiding medical educa-

tion and medical research and with the present unanimity of opinion concerning the absolute necessity of control of a hospital by the university, the duty of the latter to research is clear. If the purpose of the machinery of medical education is to "bring healing to the nations"; if "the business of medicine is to get people out of difficulties through the application of science and dexterity manual and psychical" (Cabot), then it is the duty of the university not only to teach known principles and methods, but to advance knowledge and methods by research.

It is futile to say that it is sufficient to teach and to utilize known methods for freeing peoples from difficulties, for the mere statement of such an attitude implies that an obligation exists to extend known methods or invent new ones in the hope of overcoming difficulties, acknowledged to be at present without remedy. The ethical force of this statement can not be denied. To teach a subject implies the attempt to diffuse the available knowledge of that particular subject matter among a number of people for their good as well as for the good of the community in which they live and work; equally true it is that such an attempt to teach available knowledge imposes upon the teacher the obligation to leave untried no means by which the knowledge of his subject may be increased. It is not the privilege of the teacher to leave this extension of knowledge to others. His profession of ability to teach a particular subject carries with it his obligation to the group or community he serves, of adding to his subject, knowledge of which they may avail themselves. If this applies to the individual teacher, how much more forcibly does it apply to the university with its ever-widening community and ever-increasing interests?

But ethics are frequently set aside in our practical, every-day world and even if they are not the great expense of maintaining laboratories and a hospital, an expense greatly increased if research is properly prosecuted, causes university presidents and trustees to ask what are the practical advantages of research to the university; and in those institutions which are supported, in part or entirely, by the state, this question must be squarely met.

In presenting the arguments in favor of research in the university, I will consider only conditions in this country and will not, though it would greatly strengthen the argument, utilize the experience of the German universities. One of the most important advantages, and one which should appeal to those controlling the policy of a university, is the influence on the student.

If one examines courses in the same subject in a number of schools, it is found that those which are best presented are under the control of men actively engaged in research work. Such men are alive to the advantages of new methods in their own subject and of new ways of applying old methods. Ever thinking and pondering about methods of acquiring new knowledge for themselves and their science, they appreciate better than does the non-investigator that which will aid the student to acquire knowledge, and in their teaching they bring to bear on the problems which the student has to face the same methods of attack which they use in their own researches. Under these men are assistants of the same point of view, who, ever enthusiastic about their duties as teachers, nevertheless find time for research. And it is of further interest that in these departments assistants do not long continue in a subordinate place, or at least if they do it is of their own desire, for they are early called to independent positions in other institutions. On the other hand, one finds that the men who confine their teaching to perfunctory routine laboratory courses, with a profusion of lectures, are the men who never or only occasionally contribute to the literature of their science.

In these departments, too, the teaching is a routine which, so the assistants say, gives no time for investigation; and so they remain assistants indefinitely. So, likewise, it is with the student taught under these two conditions. The student who knows that he is working in a department actively emphasizing new methods and striving to develop new truths, knows that his instruction is presented on the same basis, and thus receives that stimulus and inspiration which ensures his approaching clinical medicine with a proper appreciation of the scientific method. The student under the method of the non-investigator, on the contrary, has no incentive other than that of acquiring a knowledge sufficient to allow him to pass an examination.

An allied argument lies in the fact that the medical school that fosters research attracts the best-trained men as students. We have, as is well known to many of you, a medical school in this country which has, for several years, arbitrarily selected from a large number of prospective matriculants the certain definite number which it desires; the rest, sometimes equal to 50 per cent. of those accepted, go elsewhere. Now this school has the highest of entrance requirements and perhaps the smallest alumni body of any prominent school in the country. It

is not therefore a question of easy entrance or of the loyal influence of alumni. Nor is it a question of better laboratory and hospital facilities, for other schools have equally good equipment in both respects. Likewise it is not a question of geographic location or center of population. The enviable position of this school is due solely to the policy of combining research with teaching and of appointing to its staff teachers who, with few exceptions, are also investigators.

My contention that research in the medical school has important practical advantages to the university is, therefore, not visionary or theoretical. A policy which attracts the better-trained class of students, which improves the character of the instruction, which stimulates the student to a better type of individual effort, and which enhances the standing of the university in the community and the nation is a policy which can not be ignored by university president, trustees or faculty.

Another phase of this subject is the duty of the university in public health and other medical matters of interest to the community and essential to its welfare. State and city have always felt at liberty to call university experts to their aid in the solution of problems of administrative policy and public weal. Not infrequently, as in the case of Harvard University and the Massachusetts State Department of Health and that of New York City and New York University, the university shares with the state or city the service of expert investigators in the preparation of curative sera and the study of new methods of combating disease. In some states the university laboratories of hygiene, bacteriology or pathology are the research laboratories of the state. The problems of agriculture, of animal industry and veterinary medicine are, in the states of the middle west, largely under the control of university laboratories. It is not my desire to discuss in its general application the question of the part of the university in social service but that the mid-western state universities have solved this question in the matter of animal and plant disease and in agricultural and certain industrial problems is evident from the occasional references to the university as "the people's organized instrument of research" or "the scientific adviser of the state." This idea of social service must, and already does, to some extent, include the study of diseases of man. To what extent the latter shall develop in state universities depends upon the liberality of the state, or, as in non-state universities, upon endowment by individuals. This matter of endowment is the crux of the

research problem in its connection with the university. It is no longer possible for a medical school to be supported by the fees of its students. In the old days of the proprietary school, when instruction was almost entirely didactic, and the only laboratory work was the dissecting room, with perhaps a room for workers in inorganic chemistry and the simple procedures of so-called medical chemistry, fees sufficed and the faculty could pocket a good dividend. The increased cost of laboratory instruction in its many phases, the increase of equipment, of assistants and attendants, have made this impossible and have forced the medical schools to the shelter of universities which have resources sufficient to support medicine. But even with this aid, few schools have sufficient funds to satisfy the demands of adequate instruction and leave a balance for investigation. The result has been that universities seek special endowment for specific lines of investigation and it is unquestionably along such special lines that an increase in the facilities for research is to be expected.

A consideration of the special departments of research now existing, of the factors determining their establishment, and of the influence such departments have exerted may be worth while. It has been said by some authority on university affairs, that "the best way to get endowment is to deserve it"; and this is the principle which actuates a not inconsiderable body of men scattered over this country who by their efforts are attempting to bring forcibly before the public and university trustees the value of investigation, particularly of the preventable diseases, as a necessary and dignified type of university effort.

It is of interest to note the various ways in which research chairs or departments have been established. Some have been the result of the multiplication of chairs devoted to one general subject, as at Harvard, which has in the medical school chairs of comparative pathology, comparative physiology and comparative anatomy, each of which is quite distinct from the chairs responsible for the fundamental undergraduate instruction in pathology, physiology and anatomy. The establishment of these chairs, in part through special endowment, has greatly increased the facilities and time available for research in these fundamental branches and for special or more detailed instruction in the various activities which they represent. Likewise the splitting off from bacteriology of independent departments of preventive medicine (Harvard and Washington universities) has increased the opportunities

for the study not only of the infectious diseases, but also of those due to industrial conditions, to poverty and insufficient methods of preparing and handling food-stuffs.

Of similar origin are the departments established recently at Pennsylvania and Tulane for the study of tropical diseases. So also at Harvard an opportunity for similar effort has been made possible through the endowment of a traveling professorship in the department of bacteriology. In the same way increased facilities for investigation in chemistry has been brought about by the founding of departments devoted to physiological chemistry, independent of the older chairs of chemistry and toxicology; by the recognition of a sphere of usefulness in experimental pharmacology independent of materia medica and applied therapeutics; by departments of experimental pathology and pathological physiology, neuro-pathology and surgical pathology cooperating with or independent of the traditional departments of pathology; by the evolution in surgical teaching and research of laboratories of experimental and veterinary surgery, and, in our hospitals, of laboratories of clinical pathology. These departments, in most instances, having some instructorial duties, have an enormous influence in furthering research and in indicating the need for its extension. For the most part, whether founded on special endowment or otherwise, they are the result of an influence from within, the desire of the university authorities to increase opportunities for investigation and to improve facilities for teaching. Both these objects have been attained, and the success of many of these laboratories is a most potent argument in favor of increased endowment.

That such efforts are beginning to yield fruit, that the public is awakening to the importance of endowing research in medicine and is bringing to bear an influence from without, is shown by the increasing number of gifts, often spontaneous, for the support of investigation under the control of the university. Many of these have been made with definite specifications as to the problems to be studied, which is encouraging evidence of a special study on the part of the donors and of a keen appreciation on their part of the limitations of medical knowledge and of the need of enlarging its boundaries. Of departments thus founded, some of the best examples are those at Harvard,[1] Cornell[2] and Columbia[3] for the study of cancer, the Henry Phipps Insti-

[1] Caroline Brewer Croft Fund Cancer Commission.

[2] Collis P. Huntington Fund for Cancer Research.

[3] George Crocker Special Research Fund.

tute and Hospital, now a part of the University of Pennsylvania, for the study and treatment of tuberculosis; the department of experimental medicine at Western Reserve; the department of research medicine at Pennsylvania for the study of chronic diseases, the recently founded Sprague Memorial Institute affiliated with the University of Chicago for the study of the general problems of medicine and that recently announced by Northwestern University for the study of tuberculosis and other infectious diseases. Here also should be included the Wistar Institute of Anatomy at Pennsylvania, the work of which at present is devoted largely to research in problems of the nervous system.

Of special interest in connection with many of these foundations is the provision for investigation in the hospital in connection with laboratory work. Thus the foundation for the investigation of cancer at Harvard has its own hospital, the Phipps Institute at Philadelphia provides for the laboratory and clinical study of tuberculosis, the new Sprague Institute of Chicago has a hospital affiliation, the plans for the Memorial Institute for Infectious Diseases include a hospital for the study of such diseases, and some of the smaller foundations have been established with the understanding that the university shall ensure access to the wards of the hospital under its control. Surely the universities through the endowment of medical research will have opened to them invaluable opportunities for service not only in the investigation of special diseases, but in the broader field of the relation of social conditions to disease. In connection with the latter Dr. Richard C. Cabot has called the attention of the profession and hospital authorities most forcibly to their duty and to the opportunity for special research which this field offers. Already the Rockefeller Commission for the Study of Hook-worm Disease has undertaken the study of social conditions determining the occurrence of hook-worm disease and the University of Pennsylvania, by establishing, in connection with the Phipps Institute, a department for the sociologic study of tuberculosis, offers the first instance of a university uniting laboratory, clinical and sociologic methods in an effort to elucidate the problems of a single disease. The experiment is an important one in that union of effort in the study of a single disease, if based on the principle of social service as illustrated by the work and writings of Cabot, promises to give to university research a new field of activity; to medicine a powerful ally; and to society, an ideal of great promise for the good of the community.

To these various influences which I have presented at some length, we may, I believe, ascribe what little advance has been made in university research in medicine in this country. The same influences will continue to operate. The breaking down of the hard and fast lines which were drawn originally around the institutes of medicine will continue. As in the past, so in the future, the formation of new departments from the older departments will limit the field to be cultivated by a single individual and thus the time devoted to teaching a single subject will be divided, and as a result more time and opportunity for productive investigation will be allowed. Already immunology clamors to be released from alliance with bacteriology, hygiene or pathology; protozoology claims a domain distinct from that of bacteriology; pathological physiology demands greater recognition; and a new field—experimental therapeutics—distinct from pharmacology, is already well defined; all such expansions mean greater freedom and greater opportunity for investigation. These tendencies and the closely allied factor, the increased recognition of the hospital as a place for research (and especially the planning of groups of special hospitals, as at the Harvard Medical School), represent the forces within the university which have made progress possible. Of the forces from without which exert an influence, one, already discussed, is endowment for special investigation. A second is the influence exerted by independent institutions for research, as the Rockefeller Institute and Hospital, which by its magnificent work has stimulated the better university schools to greater effort in the advancement of medical knowledge.

A third factor is the demand of a gradually awakening public opinion that medicine should take a more prominent part, active and advisory, in the affairs of the community. The effect of this demand is already seen in the fact that the limitations and aloofness that characterized medicine in the past have already begun to disappear, and we can confidently look forward to a day when the activities of medicine, on its research and preventive sides, at least, will be—if I may so express it—imbedded in the social system, and shall live by and for it. In this connection, the university should not forget that the science of bacteriology and the knowledge which it has popularized concerning the etiology and control of disease and pestilence, formerly considered as foreordained and without remedy, has brought to the race a new hope concerning many of man's afflictions, and this hope is tinctured

with an impatient demand that all preventable diseases, whether due to infection or occupation, should be thoroughly investigated. Preventive medicine has become a great educational movement, the onward sweep of which has been accelerated by modern views concerning the treatment of tuberculosis, by municipal experience with the efficacy of water filtration against typhoid fever, the "cleaning up" in a hygienic sense of Havana during the American occupation, the wonderfully healthy state of the Canal Zone under Gorgas as compared with that in the time of the French control, the influence of a better understanding of the effect of hook-worm disease on social conditions in the south, and the importance of the destruction of the mosquito in the prevention of yellow fever and malaria. The public looks first, and naturally so, to its state and municipal laboratories for assistance, but it looks also to the laboratories and hospitals of the universities for that wise guidance and direction which, untrammeled by political expediency, is the result of impersonal scientific observation and experiment.

The problems which may be attacked by the university are both general and local; in many instances a most promising field of investigation lies at the university's door. As is pointed out in Abraham Flexner's Carnegie Report on Medical Education, the port of New Orleans offers to Tulane a great opportunity for the study of tropical diseases, and the industries of Pittsburgh offer to its university unusual material for the study of occupational diseases. The port of San Francisco, draining as it does the Orient, and soon to feel the influence of the Panama canal, offers to the university which will grasp it a field for the study of tropical and unusual imported diseases not open to any other city in the temperate zone. Industrial centers other than Pittsburgh offer advantages for the study of occupational diseases and the influence of industrial conditions. New York, Chicago and other large cities with compact populations present their own problems and even in sparsely settled rural districts arise questions of great importance.

So also every community has the problems connected with the diseases of infancy and of advancing years. The influence of bacteriology in focusing the attention of investigators and of the general public on the acute infectious diseases, though an influence of the greatest importance to medicine and one responsible for much of the endowment of research in this country, has had a tendency, on the other hand, to retard the study of diseases not due to bacteria or protozoa. The pendu-

lum now, however, is swinging the other way, and the time has come to attack, with the aid of the methods of chemistry and physiology, the chronic diseases, the disturbances of metabolism and of internal secretion and the affections peculiar to infancy and old age. Only recently have the diseases of advanced life attracted an attention commensurate with their incidence and importance. As the fruits of the investigation of the acute infectious diseases have increased the expectancy of life by diminishing the mortality of infancy, childhood and early manhood, so the study of the chronic diseases incident to middle life and advancing years, should, by the determination of predisposing causes and methods of prevention, lead not only to a still greater stability of life, but also, and what is more important, to a prolongation of years of useful activity and, perhaps, to a serene instead of painful final deletion.

This leads to the discussion of a new type of department in the medical school, departments or chairs for research only. That such departments are now necessary is the direct result of the unwise policy which, in the past, has led university presidents and medical faculties to appoint as heads of departments men who have little or no training as investigators and no interest in research. As the modern view of the duties of a medical school—teaching, the first duty, but investigation the corollary, essential not only for its own sake, but also for its influence on teaching—gains ground, university authorities find their chairs encumbered with men incapable and disinclined to conduct genuine university departments. New chairs, for research only, are therefore established in order to evade the penalty of a wrong policy and at the same time to secure men with the training and ideals of the investigator.

When university presidents learn that every professorship, clinical and otherwise, ought to be in some measure a research chair, and that research must be combined with teaching, the need for special departments of research will not be so urgent. It is true that clinical teachers are not united on this point; indeed, the weight of their opinion is often thrown in the opposite direction. For example, the anti-university conception of the university clinical professor has recently been very clearly presented by Professor Barker in an extremely plausible argument, in the course of which he proposes that two chairs should be created in the department of medicine—one for teaching and the financial prosperity of the incumbent, and the other for research! No more

objectionable proposition from a university point of view has ever been made. Officially recognized and sanctioned separation of research from teaching, especially in the clinical chairs, would not only place the university on the level of the secondary school, but would delay all progress in medicine, and, more important still, destroy what little confidence the public is beginning to have in the altruism of university medical education. Let us hope that such counsels may not prevail. Let us work for the recognition of the principle that teaching and research should be combined in *every* department of the medical school. In the meantime, special departments of research may well be created, not only to make up for the sterility of the other chairs, but in order to attack problems that are of such magnitude and complexity that they may well engage the entire time of those devoted to them. But neither research professorships nor research institutes can ever relieve the professor of medicine or of surgery from the duty and obligation to continue to be creatively occupied in the development of their respective departments.

Existing departments of research are variously described as departments of experimental pathology, experimental medicine or research medicine. The title matters little, but the plan of the department should be broad enough to care for the problems of clinical medicine, and for this reason the word "medicine" should appear in the title rather than the word "pathology." Such a department should keep in close touch with the department of clinical medicine, should supplement the facilities of the various hospital laboratories, and should also work in cooperation with the fundamental laboratory sciences in order to insure no loss of opportunity in the prosecution of its problems and thus a realization of the greatest good to the school. The head of the department should be a man familiar with the problems of clinical medicine, trained preferably as a pathologist, and with sufficient knowledge of the possibilities of physiology and chemistry to apply the methods of these subjects to clinical problems. I say preferably a pathologist because the pathologist is more apt to combine clinical training with a knowledge of pathology, bacteriology and the principles of immunity than is the physiologist, chemist or pharmacologist, though any one of the latter might well head such a department. Certain it is that whatever his own training may have been, the director should, with his assistants, be able to utilize in the work of the depart-

ment the methods of physiology, chemistry, bacteriology and experimental pathology. In other words, he should have a department capable of attacking a problem in medicine from any or all sides, including that of experimental therapeutics; and in order to make the work effective, he should have the use of beds in the university hospital.

The work of this department should be the investigation of clinical problems, and not of academic problems of pathology, chemistry or physiology. General practitioners, clinical assistants in the school and even those at the head of clinical departments are constantly meeting problems which demand solution, but find no adequate opportunity to investigate them in departments as now constituted. These men would find a place in the department suggested and should constitute an enthusiastic working staff which should be exceedingly productive in the advance of medical knowledge.

I may be over-enthusiastic about this matter, but I believe that departments such as I have outlined are a necessary part of every large university medical school, and must be developed eventually through the combined efforts of the pathologist and the clinician, who have naturally a greater interest in the problems of disease than have the men of other departments and who must have a research department devoted to their common interests.

A department of this type, whether independent or affiliated with the chair of medicine, I would recommend to every university which sees its way to procure endowment for research in medicine, for in a department of such broad scope lies the possibility of attacking many problems in the broadest way and of assuring the best utilization of endowment and the greatest good for the greatest number.

This discussion might be lengthened by the presentation of other phases of the subject of medical research, but I may well end with Mr. Eliot's all-inclusive characterization:

> Medical research habitually strives to arrive at something beyond abstract truth. It seeks to promote public and private safety and happiness, and the material welfare of society. Its devotees have in mind the discovery of means of remedying misery or warding off calamity; and they know that whatever contributes to health or longevity in any community or nation contributes to its industrial prosperity; so that they are justified in hoping for results from their work which will promote human welfare.

If my presentation of the subject of research in medicine, which now comes to its close, has any value it lies in an attempt to demonstrate

two things: (1) That, wonderful as were the isolated achievements of the great discoverers in medicine in the early centuries, the great continuous advance in medicine during the past eighty years resulted from organized laboratory effort based on the principle of exact experimental methods, and (2) that it is the duty of the university so to organize its laboratories and hospital that this advance of medicine by research may continue, side by side with teaching, as a university function of benefit to student and faculty, as well as to the state and the general public welfare, and thus as an aid to the advancement of civilization.

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THE EXPERIMENTAL METHOD: ITS INFLUENCE ON THE TEACHING OF MEDICINE[1]

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When I was invited to address this society and it was suggested that I take as my subject the methods of experimental medicine, I experienced more than the usual pleasure afforded by such an invitation, for it offered me not only a rare privilege, that of addressing in a formal manner the student body of the school in which I once labored as student and instructor, but also the opportunity of acknowledging my indebtedness to various members of your faculty, past and present, who by their methods of instruction gave me my first insight into those experimental methods and scientific procedures on which all that is of value in medicine is based. For example, my first lesson in exact observation was given me by Dr. Minot in one of my earlier exercises in histology. I was, as were at that time many students of this school, poorly prepared in the experimental methods, but well versed in the methods of using a text-book. I thought I knew from my reading the essential details of the structure of a cell, and accordingly prepared with ease and rapidity what I considered to be excellent pencil sketches of the material offered in the first few days of the course. I remember well my incredulity and then my amazement and chagrin when Dr. Minot demonstrated to me that I had not drawn the cells I thought I saw under the microscope, but the cells visualized from the text-books. Even to this day I do not see a frog without calling up that picture of the frog's epidermis, of Dr. Minot and of my first lesson in exact observation; a lesson which it may please Dr. Minot to know I consider the most valuable single lesson of my experience. I can remember nothing else about that course in histology, but that one lesson I have never forgotten. This training was continued by others, but particularly by Dr. Councilman and Dr. Mallory, not only when as a

[1] An address given under the auspices of the Alpha Omega Alpha Honorary Medical Fraternity, Harvard University. Published in the *Journal of the American Medical Association*, 1911.

student I received my instruction in pathology, but also during several delightful years as assistant in the Department of Pathology. To these and other members of this faculty, past and present, I owe my early instruction in the methods of scientific investigation and much of stimulus and encouragement, and to you, for the opportunity you have given me of expressing this appreciation of my debt, I am sincerely grateful.

The phase of experimental medicine which I am about to discuss is not, perhaps, that which your secretary had in mind when he suggested as a subject "Experimental Medicine; its methods, what it has accomplished; the problems before it; and what it may hope to do in the future." These specifications might easily have been fulfilled by a compilation of the achievements and accomplishments of scientific medicine, detailed in historical sequence or grouped about the activities or methods of some particular field of endeavor. Of late, however, so much has been written along these lines that I fear such a presentation might have a familiar, laudatory tone, and leave you with a feeling of too great complacency concerning the progress of our science. I intend, therefore, while still adhering to the formula set me, to neglect the triumphs of the investigator and to point out, at the risk of being misunderstood, the importance of the experimental method in the every-day work of the student and the teacher of medicine; and how, if conscientiously applied, it may thus exert a powerful influence in the development of the science of clinical medicine.

First, a word may be said about the experimental or scientific method. According to Minot it is "the right method of ascertaining the objective truth" and differs from our every-day methods only in its precision; according to Von Baer it is "observation and reflection"; Huxley characterizes it as "nothing but trained and organized common sense." It is the sentiment expressed in Sir Astley Cooper's "First observe and then think." I doubt not that these expressions are familiar to you all, that you are accustomed to the procedures they describe, and have benefited by their application in the hands of your instructors. If so you are more fortunate than the great bulk of medical students; for it is my profound conviction that the greatest fault in our medical teaching is the failure of the majority of teachers to practise, when in actual contact with the students, those scientific methods which they recommend in theory, and which some of them vigorously apply in

their own investigations. This is a sweeping statement, but it is based on my personal experience as a teacher in nearly half a dozen schools and on an intimate knowledge of the methods of instruction and of the men giving the instruction in at least a dozen more; and, moreover, it is made with a full appreciation of the wonderful advance in laboratory instruction in all branches of medicine during the past fifteen years. My statement, I realize, must be supported, and as my proof must be more or less in the nature of criticism, the task I have set myself is not a pleasant one. In fact, I would not have entered into this discussion if it were not that our product, our graduate in medicine, has been found wanting by the German finishing school. Professor Graham Lusk, than whom there is no more fearless champion of scientific idealism, stated in a recent address that a friend was told by a prominent professor of medicine in a German university that the greater number of young Americans who came there to study were "no good." Twenty-five years ago such a statement would not have been surprising, but now, with our much-vaunted laboratory methods and our improved clinical teaching, the statement is, to say the least, discomfiting. The "greater number" of American students going abroad may be from the poorer schools, and if so, which hardly seems probable, the criticism is unjust to our schools of the better type. If, however, it represents the true condition, from the German point of view, then, as Lusk puts it, "our educational system is at fault. It can not be that American intellect is inferior. The trouble lies in our system."

It is these statements which have crystallized my own misgivings as to the shortcomings of our methods of instruction. These shortcomings may occur in the laboratory work of the first two years or in the clinical work of the third and fourth years, but the teachers in the laboratory years are responsible for the point of view with which the student approaches the material of the clinician, and they should consider it not only a duty, but a privilege and an opportunity of the greatest moment, to train the student in method and in accuracy of observation. If the teachers of the first and second years do their duty in this regard the student himself will demand and obtain better teaching the third and fourth years. Do the heads of our laboratory departments always grasp this opportunity? Is this opportunity grasped by the man who sees his class only as it is seated in the amphitheater, who lectures four or five times a week and never or

hardly ever goes into the laboratory where his students are at work? And what shall we say about the man who reads his lectures, the students acting the part of efficient stenographers, fearful of missing a word, because, without emphasis of important points, they must get every word for the necessary and inevitable cram? And then, most ludicrous of all, the man who lectures from his own text-book, his auditors not taking notes but underlining the text of the same book? There must be something of peculiar dignity in the professorial utterance, which I must admit I have never appreciated, to allow the perpetuation of this method. Better that such teachers should sell their dignity in the form of text-books or printed notes, at a profit, than that they should waste their own time, as well as that of the men they thus vainly attempt to teach. One of your faculty writes thus of the lecture: "The very best that can be said of a lecture or a book is that it describes well the knowledge which some one possesses. A book or lecture can serve only to assist a man to acquire knowledge with lessened loss of time. Knowledge lives in the laboratory; when it is dead, we bury it decently in a book" (Minot). One may add that a lecture on knowledge thus decently buried in a book is itself deadly in its influence on the student.

Complete, voluminous, detailed lectures may have been necessary in the days of poorly prepared students, but with our present requirements in physics, chemistry, biology and the languages they are unnecessary. The department head who inaugurates his week's work with a general summary of the character of the laboratory exercises of that period, emphasizes the important phases of the subject and suggests the matter to be read, can leave the details which take the time of the second, third, fourth and fifth lectures to the student himself and to amplification in the laboratory. Or, if this does not suffice in his mind to present the subject-matter properly, a second hour with the lantern is worth half a dozen formal lectures. At the end of the week, after the laboratory work is completed, a third hour, for a conference recitation, which he conducts personally, should clear up all doubtful points. In this recitation the men should not be marked; it should be an informal affair, with the sole object of determining the efficiency of the week's instruction and of the progress in the power of observation and deduction. Such a method always succeeds. I have tried it for three years, in two different schools, always supplementing it by per-

sonal attendance in the students' laboratory, and my experience is such that I usually apologize for the occasional extra lecture now and then apparently necessary.

A student of medicine in New York City, in 1906, presented in the correspondence columns of one of our medical journals a very accurate picture of the evils of the lecture system. Referring to the good, average student, he says: "Such a student goes to the (medical) school anxious to learn. Five to one he does not know how to learn; ten to one he does not know how to think! During the first two years he has forced on him such a cold douche of slippery facts that his warm young enthusiasm is chilled to the marrow." I think most students who are freely lectured to will agree with this critic. Complete presentation of a subject in a lecture, even though the facts be retained, stifles curiosity and inquiry, turns the interest of the student backward instead of forward, and retards the development of that scientific method of thought so satisfying as a part of one's mental equipment. Complete and voluminous lectures, which discourage collateral reading and minimize individual laboratory work, force the student to consider the final examination to be the ultimate object of the course. In some schools the student is encouraged in this point of view by the establishment, often with the consent and approval of the head of the department, of extramural quizes, which, given by assistants of the department, increase the income of the latter at the expense of the student's mental development. This system can not be too severely condemned, and it is a favorable omen that we find it no longer countenanced by conscientious teachers trained in modern methods. The latter discourage voluminous note-taking and advise the student to take merely an outline of the lecture and then to supplement this by independent reading and by personal observation in the laboratory. This places the student in the position of an investigator who reaches his conclusions more or less independently and thus gains both in method and in power. Errors in interpretation can always be corrected by a weekly conference-recitation held by the head of the department, and this method has in my experience been so highly esteemed by the student body as not only to kill the extramural quiz, but also to increase greatly the capacity of the student for independent work.

Another fault of the lecture system is the not infrequent arrangement which allows the head of the department to consider lecturing

his only duty and permits him to turn over the laboratory work to assistants. If the laboratory instruction is to be not merely a matter of perfunctory routine, but is to be used for training in the experimental method with the object of developing power in method and in observation, it becomes one of the most difficult forms of teaching, and no matter how adequately trained the assistants may be, the daily presence of the head of the department, if he have the proper point of view, is essential to the success of the laboratory instruction. Some of our teachers in anatomy and pathology have been so impressed by the advantages of this system as to abandon all formal lectures. If I were forced to a choice I would cling to the privilege of teaching in the laboratory and turn over the lectures to my assistants.

I am not, however, one of those who believe in abolishing the didactic lecture. Combined with demonstrations and laboratory work it is of great value, in the proportion of about one hour of lecture to six or eight hours of actual laboratory or clinical work by the student, but the manner in which it is overworked in some branches, as anatomy, a subject which has its laboratory material always at hand and in abundance and is not handicapped by the absence of excellent text-books, leads one to believe that the lecture thrives merely because it is from the instructor's point of view the easiest method of teaching. On the other hand, in some subjects, as physiologic chemistry, pharmacology and immunology, in which advances are being rapidly made and which for this reason have no adequate text-books, frequent and complete lectures are necessary.

Let us now turn to the instruction in the laboratory itself, where we should certainly expect to find experimental methods conscientiously practised. We have every reason to be proud of the equipment and facilities of most of the laboratories in our better medical schools. In no country has the idea of laboratory instruction so rapidly advanced as in America. Visitors from European schools express amazement at our complete outfits for the individual student. Expensive as such outfitting has been, university trustees have met the demand willingly and their attitude in this respect has been one of the most pleasing phases of the recently awakened interest in proper education in medicine. Thirty institutions, according to the recent Carnegie Report on Medical Education, have well-equipped laboratories to teach the medical sciences. With the other hundred-odd schools we are not concerned,

for these, if they do not establish proper laboratories, must cease to continue as factors in medical education. And of the thirty my remarks, I may say, refer only to the best, to those which are ambitious to properly present the scientific side of medicine in a really scientific manner. Do the teachers of our best schools always keep in mind that their chief function is the training of the physician and that for this purpose the constant application of the experimental method is essential?

The guiding principle of laboratory instruction should be the practise of the "do it yourself" idea. Lectures, amphitheater demonstrations and recitations should, if time can not otherwise be obtained, give way to actual individual work in the laboratory. Furthermore, the department head, without sacrificing the presentation of his subject as a training in method, should prominently place before the student its relation to other courses in the medical curriculum, and especially to the clinical work which is to follow. This latter view is, I know, opposed by some of our most prominent teachers of physiology and chemistry, but as the first object of a medical school is to train physicians, we must teach applied science as well as pure science.

Nearly all our laboratory courses offer opportunity for criticism from these two points of view. Anatomy, aside from the error of overlecturing, is perhaps least at fault, for abundant material for dissection makes this course, if the material is properly utilized, an ideal one for the practise of the "do it yourself" method. The related subjects, histology and embryology, may, however, be criticized in that they are seldom taught in relation to one another or to gross anatomy, and practically never with a regard to the work in physiology and pathology which follows. Of the few exceptions, Huber's course at Michigan best illustrates how these subjects should be presented. Embryology forms the basis of the work in histology; the student studies cell division and the development of the germ layers, and as the tissues and organs are differentiated the histology of each is studied in adult tissues. Thus the structure of each adult tissue and organ is brought into relation, on the one hand, with its origin and its order of development, and, on the other, by judicious correlative teaching, with important basic principles of pathology; as, for example, the general laws concerning the origin of tumors, or the similarity of the repair or regeneration of an adult tissue to the embryonic development of the

same tissue, or the developmental explanation of the anatomy of hernia. These and other important fundamental principles can be taught better by the embryologist than by the pathologist.

Another neglected field is that on the border-line between histology and gross anatomy, which for the want of a better name may be called "semi-gross" anatomy. The well-trained student can from memory give a fairly accurate description of the relations and gross external appearance of an organ and also of its histologic structure, but he is at sea when asked to point out on the freshly cut surface of an organ its normal markings. The appearance of the Malpighian bodies of the spleen, of the glomeruli of the kidney, the differentiation of arteries or veins from the bronchi in the lung or from the bile-ducts in the liver are matters of which he knows nothing. His theoretical knowledge fails when put to the practical test. This is due entirely to the fact that the gap between the experience of the dissecting room and that of the histologic laboratory is hardly ever filled, as it should be, by the study of fresh organs in the latter course. Properly to correlate the teaching of embryology, histology and anatomy is one of the most important duties of the department of anatomy.

It is, however, of the work in physiology, pathology, bacteriology and pharmacology that I wish especially to speak. The first and second of these sciences are concerned essentially with normal and abnormal functions, the third with one phase of the etiology of altered function and the fourth with the treatment of abnormal function. They therefore lend themselves to teaching from the dynamic rather than from the static or descriptive point of view, and are peculiarly adapted to the procedures of the experimental method. These are subjects which offer the possibility of bringing the student closer to an understanding of the manifestations of disease, and the factors which cause and influence these manifestations, than any other group of subjects in the medical curriculum. Physiology and pathology should be so taught as to force the student and physician to think physiologically and not morphologically, as is usually the case. The close adherence of both of these sciences to the descriptive method may be explained historically in the case of physiology by the development of physiology by anatomists, physicists and chemists rather than by biologists in the broad sense. The influence of the descriptive anatomist is seen in the early association of histology with physiology; of the physicist in the early

electrophysiology, and of the chemist in the early analytical trend of physiologic chemistry. Likewise, pathology, adopting the methods of anatomy, became a purely descriptive science, seeking the seat of disease and concerned with the appearance of diseased tissues. I have no desire to minimize the importance of this anatomic conception, for it has been, under the stimulus of Virchow's genius, one of the most important principles in the history of medicine and most fruitful as a guide to investigation. But Virchow's conception was not narrow and his writings continually reveal, as does also the title of his *Archives*, his appreciation of the importance of physiologic and other experimental methods in the study of pathology. Such methods, however, were seldom applied, and, with the exception of Cohnheim's brilliant work in pathologic physiology, the descriptive point of view continued, despite the rise of bacteriology, which likewise was treated by pathologists as essentially a descriptive science, until the genius of Ehrlich offered the impetus to a dynamic conception.

In investigation, the descriptive point of view is now subordinate, but in teaching it still persists. The student in physiology, in many schools with well-equipped laboratories, never works with an animal higher than the frog. Such a course in electrophysiology, essentially a course in physics, with a few exercises devoted to the use of mechanical models and perhaps a few amphitheater demonstrations, is considered sufficient training for the work which soon follows, in the instruction, for example, in physical diagnosis. The student enters on the latter work, which many consider the most difficult part of their course, with no first-hand knowledge of the important phenomena of circulation and respiration, which might readily have been presented by the use of mammals. One of the most useful instruments of the physician, the stethoscope, of great value also in the teaching of physiology, is seldom utilized. In many courses the physiology of respiration and circulation is completed without the student having heard the respiratory murmur or the heart sounds. The physiology of the kidney, the pancreas and the ductless glands is taught by lecture only, or by an occasional amphitheater demonstration. In such departments we usually find the man who lectures four or five times a week and leaves the laboratory work to his assistants. As a teacher of pathology I believe the "frog" course, unaccompanied by work on mammals, worse than nothing, for the student thinks "frog" and not physiology.

He gets his mammalian physiology for the first time when he takes his course in experimental pharmacology. If the latter course is not provided by the curriculum—and unfortunately in many schools it is not—he does not get it until as a practitioner he experiments on man.

Bacteriology, one of the most modern of the medical sciences, suffers likewise from the descriptive method. It is, in the majority of schools, a course in the descriptive botany of the fungi. It is true that the student actually handles the bacteria, studies their morphology and observes their behavior in artificial media, but their behavior in the animal body is left to lectures. The all-important lessons of bacteriology—the problems of infection and immunity—the student has no opportunity to study at first hand. What a live subject bacteriology may be for the student is seen in those few courses in which he reproduces in animals the lesions caused by the microorganisms which he studies, and carries out those experiments which illustrate the fundamental principles of immunity. He can have no better training in the experimental method than that which comes from following half a dozen different bacteria from pure culture through the lesions which each produces in an animal and back again to pure culture. Likewise, the experimental study of active and passive immunity, even if the latter be only the simple testing of the protective power of diphtheria antitoxin, is invaluable. If to these is added the practical study of hemolysins, agglutinins, precipitins and of the phenomena of hypersusceptibility, bacteriology as applied to medicine is actually taught. From the practical point of view, the training offered by animal inoculations is of the greatest importance for the proper appreciation of the principles of asepsis in surgery, while the work in immunity aids the student to grasp intelligently the pathology and therapy of the transmissible diseases.

It is a matter of great doubt if in the better schools to which students come with a general training in biology it is necessary to give as much time to the purely morphologic study which consumes so much time in the average course in bacteriology. Certainly this phase of the subject, with the abundance of excellent text-books which we possess, does not demand the number of lectures usually devoted to it. The present methods do not give the student an adequate general conception of the rôle bacteria play in disease, and of specific effects they have no knowledge which they can readily apply to their work in

pathology. As a teacher of pathology my experience has been such that I take it for granted that the student knows something about the tubercle bacillus, the diphtheria bacillus and the gonococcus; but as to the other pathogenic bacteria I have found it just as well to assume that their knowledge will not lessen the labor of the instruction in pathology. As to their knowledge of the difference between bacteria and protozoa it is enough to say that the ameba of dysentery is usually designated as *Bacillus amebæ* or *Bacillus amebæ coli*, and *Bacillus malariæ* is not uncommon. If the biologist and the modern physiologist can utilize our common protozoa in an experimental course, why not the bacteriologist to such an extent at least that the medical student may learn the difference between a bacterium and protozoon?

And what is to be said of pathology? I may perhaps be criticized for what I have said about physiology and bacteriology on the basis that I have not taught these subjects and am not familiar with the difficulties which they present. This criticism certainly can not hold when I say that I consider pathology, as it is usually taught, the most forlorn course in the medical curriculum. Lectures in great abundance, illustrated by museum specimens enclosed in fluid and glass and sections of diseased tissues sandwiched between glass is the story in nine out of ten courses. Even when fresh material is supplied in satisfactory amount, a gap still remains—that great gap representing altered physiology. I do not wish to decry any means by which a knowledge of pathology may be presented to the student, but an adequate collection of specimens representing the gross and microscopic appearance of diseased tissues should, I believe, be considered as only the essential minimum of equipment. Neither do I wish to minimize the importance of morphologic study, for it is the cornerstone of that modern pathology on which sound diagnosis and rational therapy rest; but the teachers of men who are to spend their lives in the study of the manifestations of altered physiology should not magnify the morphologic aspect of pathology at the expense of the dynamic. This phase of my subject in so far as it refers to investigation has been very ably discussed from the point of view of the chemist by Professor A. E. Taylor; and the possibilities of physiologic methods in teaching pathology to small groups of students have been clearly demonstrated by Professor W. G. MacCallum. So ably have they presented their claims that I can add but little that is original. My personal experience may,

however, be of some value as an illustration of the evolution of a point of view. Trained as a morphologist of the most uncompromising type, I became interested, after several years, in the methods of experimental pathology and gradually awakened to the importance of the investigation of altered function. A desire for a greater knowledge of the methods of physiology and chemistry followed. At first this new knowledge was utilized only in investigation, but a troubled conscience soon led to its use in the teaching of pathology. At first, experimental demonstrations before the entire class were introduced here and there in my courses, but in such a fragmentary way that they were of no more value to the student than the usual set demonstration of the chemist. This year, for the first time, I found myself with sufficient space, equipment, time and assistants to inaugurate a systematic course in experimental pathology and pathologic physiology in such a manner that each student would get something out of it. Without going into the details I may say that by giving two hours a week to the course and dividing the class in two sections, each student of a class of ninety men had fourteen exercises of an hour each, and by presenting in each hour five different demonstrations simultaneously, no one demonstration group numbered more than nine men. That is, about seventy experimental procedures, phenomena or lesions, were shown each man, for each of which he had twelve minutes and was only one of a group of nine. I give these figures to show the possibility of carrying out experiments of this nature with large classes. The planning of the course is no small matter and the labor of preparation is great, but the actual demonstrations are not difficult, and even if they were the change in the attitude of the student toward pathology which such a course brings about makes it well worth while.

These demonstrations included the presentation of necrosis and the degenerations; inflammation and repair; blood-destruction and jaundice; thrombosis, embolism and infarction; certain lesions of the heart, lung, stomach and intestines, liver, pancreas and kidney; the problems of infection and immunity, of shock and hemorrhage, and the physiology of the ductless glands. Physiologic methods of graphic registration were used whenever possible, changes in the urine and other secretions demonstrated, and the methods of clinical diagnosis emphasized. A few details of some of the exercises may illustrate the advantages of this course. The pathology of blood-destruction and jaundice, the

circulatory changes in heart disease, and the pathology of the pancreas are subjects always difficult for the student to grasp; and, moreover, almost impossible of demonstration by morphologic methods. The exercises on these subjects may therefore serve as examples. Blood-destruction and jaundice were illustrated by five demonstrations: (1) the production of hemoglobinemia and hemiglobinuria by the administration of crotalus venom, and (2) the injection of hemolytic immune serum. The associated changes in the spleen and other organs were demonstrated, as was also the laking of the blood in centrifuged serum. The naked-eye appearance of the urine was contrasted with that of (3) hematuria due to cantharidin, as were also the albumin content and sediment of the two types of urine, and the use of the spectroscope was demonstrated. By test-tube experiments the phenomena of (4) hemolysis and hemagglutination were explained, and thus the theory graphically brought into relation with the changes in the animal body; (5) obstructive jaundice due to ligation of the common bile-duct was shown, the urine of this animal contrasted with that of the hemoglobinuric animals as to the presence of bile and albumin, and by comparing these animals the clinical signs of obstructive and hemolytic jaundice were clearly shown by examination of the skin and conjunctiva.

In the exercise on cardiovascular disturbances the changes in heart action, blood-pressure, pulse-rate and volume, and in respiration as a result of experimental (1) aortic insufficiency, (2) mitral stenosis, (3) hydropericardium, (4) injury to myocardium and (5) edema of the lungs, were graphically demonstrated by the use of a kymograph.

Acute diseases of the pancreas were illustrated by (1) experimental acute hemorrhagic and (2) gangrenous pancreatitis due to the injection of bile, with (3) the correlated fat necrosis. The relation of the pancreas to diabetes and the theory of internal secretion were demonstrated by contrasting the results of (4) extirpation of the pancreas with (5) ligation of the pancreatic ducts. The fermentation and Fehling's tests applied to the urine of all these animals offered a vivid picture of the relative influence of different types of injury of the pancreas.

These three exercises are examples of the opportunities offered by this method of teaching. The advantages of its application to the problems of nephritis, the disturbances of the ductless glands and the

principles of infection and immunity are evident. No other part of my teaching experience has ever given me so much satisfaction with the attitude of the student, and in no other course have I felt so certain that I was giving him what he wanted and needed. Such a course is, after all, as near an approach to clinical methods as one can attempt in the laboratory. The physician studies the altered functions of his patient by direct observation and by all the methods which biology, physics and chemistry have brought to bear on diagnosis; he summarizes the results, correlates them, ponders over them and arrives at a conclusion which is based largely on the fundamental experience of pathologic anatomy. His work really represents the first, the oldest and the most important application of pathologic physiology. Is it not rational, therefore, to prepare the student for his study of the pathologic physiology of man by similar studies on the lower mammals? To let him produce, or see produced, certain anatomic lesions and study the alterations of function which result, applying thereto many of the clinical methods, and eventually at autopsy to correlate the disturbances in physiology with the anatomic changes, is, I believe, a most valuable preparation for clinical study, in that it bridges the great gap between pathologic anatomy and clinical observation.

Another phase of the teaching of pathology which may be criticized is the presentation of pathologic anatomy. Diseased organs are studied from the point of view of changes in morphology, color and consistence, without attempt to associate physiologic disturbances. In many schools no systematic work in gross pathology is offered after the second year, and even in the second year it is usually a museum course with no systematic drill in fresh appearances. Some schools have improved the situation by obligatory autopsy work and clinico-pathologic conferences in the third and fourth years. Also the museum material has had some life instilled into it by adopting the "case" system of presenting organs illustrating the associated lesions of any one disease with, at the same time, the clinical history and microscopic preparations. But all these improvements leave the work a demonstration course. The student can obtain an adequate knowledge of morbid anatomy only by following the example of the young pathologist; that is, by studying at first hand the naked-eye appearance of fresh organs, arriving at some conclusion, and immediately verifying it, or otherwise, by the use of the freezing microtome. This is the true experimental

method—observation, hypothesis, experiment, deduction. It is perhaps best combined with the work of the third and fourth year of medicine, after the student has had a year of fundamental pathology, though if time allows it can also be used in the second year. During the past four months I have used it with my third-year class and have had the most gratifying results. Placed in a room with the fresh material before them, with scales, measures, the necessary dissecting instruments, a bacteriologic outfit, stains and reagents for microchemical reactions, an abundance of text-books on all branches of medicine, and a laboratory attendant at the freezing microtome, the men have worked out their own diagnoses at first hand. No demonstrations were given and no aid, except in guiding methods of procedure and by occasional pertinent questions. At the end, diagnoses were checked, and each student's general knowledge of the lesions he had studied was determined by a few leading questions as to etiology, associated conditions, complications, sequelæ and important clinical symptoms. The eager attitude of the class toward this course has been sufficient evidence of its value.

Professor Chiari, to whom so many of our teachers of pathology owe their early training, during his recent visit to this country, investigated our methods of teaching pathology. The account of his impressions published on his return to Germany is for the most part very pleasing, but he criticizes justly the insufficient use of fresh autopsy material.

We have not the wealth of fresh autopsy material offered by the pathologic institutes of Germany, but that which we have is too frequently used for perfunctory demonstration or for second-hand study as beautifully mounted and labeled museum preparations and not sufficiently utilized for first-hand observation and manipulation by the student. The use of fresh material and the freezing microtome go far to wean the student from his "reverence for authority" and his faith in the lecture and to force him to observe and think for himself.

Physiologic chemistry and experimental pharmacology, as given in our best schools, are, I believe, the most satisfactory of our laboratory courses. Presented, in most instances, in a vigorously scientific manner, with the student carrying on exact quantitative estimations and using graphic methods of registering results, and himself frequently the object of experiment, these courses fulfil all the rules of the experi-

mental method and force on the student, as no other course does, the practical importance of this method. To one who was taught by the methods of the old "medical chemistry" it is most stimulating to see an entire class in modern physiologic chemistry study the influence of a protein, a fat or a green diet, of a nuclein diet on purin output, of a heavy protein diet on urea output, and of starvation on total nitrogen and acetone elimination. In these, as well as in other procedures, as individual calorimetry with the respiration apparatus, the student is the investigator as well as the experimental animal. Such experiments are now extensively carried out in a few courses, and when supplemented by the study of phloridzin glycosuria, pancreatic diabetes and other experimental conditions in animals, give a knowledge of the fundamental principles of metabolism and of practical physiologic chemistry which was not dreamed of by the student of ten years ago. Such courses lead one to believe that the rapidly approaching closer union of hospital and school will lead to the next step, the opportunity for small classes to study the metabolism of patients in the hospital ward.

The modern course in experimental pharmacology, unfortunately at present not given in all our better schools, is, I believe, the most valuable part of the first two years of laboratory work. Coming as it usually does in the latter part of the second year, when the student is completing or has completed his physiology and pathology, it offers him the last opportunity, before he approaches the clinic, to review normal functions and to study the manner in which various agents may alter them. And in those courses which are not merely exercises in testing the action of drugs, but in which abnormal conditions are produced and measures for their treatment or care are applied, pathology as well as physiology is reviewed and the fundamental principles of therapeutics thoroughly impressed on the student's mind. Not only medicine, but surgery, benefits by such a course, for the study of the influence of anesthetics and of the production and treatment of shock, collapse and hemorrhage carries the student well into the realms of clinical surgery. I refer, naturally, not to demonstration courses, but to those in which the procedures are actually carried out by the class; a course without which no school can be considered as fulfilling its duty to the future practitioner of medicine, for it not only continues the training in methods, but gives the student "an insight into the possibilities and limitations of treatment by drugs which will protect

him from a pessimistic nihilism on the one hand, and even more important, from uncritical enthusiasm on the other. The student thus trained will be less likely to fall a prey to the proprietary-medicine manufacturer and the nostrum monger than the physician who has obtained all his knowledge concerning the action of drugs from books, lectures or the circulars of manufacturers" (Barker).

In presenting this criticism I am not unmindful of the recent great advance in the utilization of laboratory teaching, and I realize fully that suitable equipment for teaching must precede the elaboration of methods of teaching. This equipment we now have in all good schools and I feel very strongly that the time has arrived for the heads of the laboratory departments to justify its great expense by so conducting their courses as to satisfy, on the one hand, the students receiving the instruction, and, on the other, the trustee or others providing the equipment. But, above all, they must themselves be satisfied that their courses, collectively, leave no gaps which might, with a little thought and a little cooperation, be filled. Some of these gaps, as, for example, those I have mentioned in connection with bacteriology and pathology, could be filled by new departments of immunology and pathologic physiology, but the already overburdened medical curriculum can not yield more time. Correlation between various departments and a rearrangement of old courses on a modern basis, with the object of training for power rather than knowledge, must be one of the remedies. The present evil is the result of a lack of general supervision. Professional dignity frowns on interference in the affairs of a department, and suggestions are not always kindly received. It is probably for this reason—fear of offending a colleague—that criticism has seldom been brought to bear on this point; indeed, it appears to have escaped the all-seeing eye of the able representative of the Carnegie Foundation. One remedy, therefore, is open criticism backed with authority, and that authority should reside in a committee of the governing body of the university. This is the most direct way to bring about a proper correlation, but not perhaps the best way.

Another method is by voluntary cooperation on the part of the heads of the laboratory departments, with free criticism one of another and helpful suggestions for each other's department. This fails sometimes, when a considerable number of years separate the training of one department head from that of another, but usually the spirit of

mutual helpfulness wins. Our medical sciences are not, for the most part, so widely separated that the members of one department are totally ignorant of the methods of another. Their interrelation is best illustrated by the development of embryology in the departments of anatomy, physiology and zoology simultaneously; by the influence of pathology on physiology and on the development of certain phases of normal histology; by the position which bacteriology and protozoology occupy in the departments of pathology and hygiene; by the development of a new science, modern pharmacology, based on the application of the methods of chemistry and physiology to empirical therapeutics; and by immunology, as its followers now term it, which demands the methods of practically all the medical sciences.

Despite this history of development and mutual relation there is a tendency, not only in teaching, but in investigation, to separate sharply each of these into an independent science of medicine to the great detriment of that which should be the scientific aim of all, the development of the science of clinical medicine. Even though this last science is to reach its perfection only through the efforts of men actually engaged in clinical research, as is the opinion of Dr. S. J. Meltzer, such men must receive every advantage of training in the fundamental medical sciences, and not only this, but from the teachers of such branches they must receive so much of the scientific spirit that they will carry some of it with them into their clinical work. I do not mean by this that clinical surgery and medicine have not men of scientific methods and investigators of prominence; I mean rather that they would have more if the teachers of the first two years so correlated their work as to force on the student the practical use of their methods in the investigation of clinical problems, or, what is simpler still, demonstrated the relation which the methods of one course bear to those of another course in the explanation of the phenomena of abnormal function. This latter is particularly the opportunity of the courses in physiology, pathology and pharmacology. I once taught in a school in which these courses were given to the same class in one year. The heads of the departments were men of about the same age, of the same general type of training and each interested in demonstrating the value of the method of his particular laboratory course as a training for clinical medicine. We so arranged our courses that the presentation of the pathology of certain organs was frequently preceded or followed in either the laboratory of

physiology or pharmacology by a demonstration of such functions as could be graphically shown, with, whenever possible, disturbances of such functions due to the action of drugs or experimental injury. The benefit of such cooperation can not be denied and illustrates a second of the possible remedies for the present isolation of our laboratory courses.

Another important phase of this subject is that of the relation of investigation to teaching. If one examines courses in the same subject in a number of schools, it is found that those which are best presented from the point of view of the experimental method are under the control of men actively engaged in research work. Such men are alive to the advantages of new methods in their own subject and of new ways of applying old methods. Ever thinking and scheming about methods of acquiring new knowledge for themselves and their science, they appreciate better than does the non-investigator that which will aid the student to acquire knowledge, and in their teaching they bring to bear on the problems which the student has to face the same methods of attack which they use in their own researches. On the other hand, one finds that the perfunctory routine laboratory courses, with a profusion of lectures, are by the men who never or only occasionally contribute to the literature of their science. Under men of the first type, one finds assistants of the same point of view, who, ever enthusiastic about their duties as teachers, nevertheless find time for research. And it is of further interest that in these departments assistants do not remain for long periods, or at least if they do it is of their own desire, for they are soon called to independent positions in other institutions. In the department of the second type, the teaching is a routine which, so the assistants say, gives no time for investigation; they remain assistants indefinitely. So, likewise, is it with the student taught under these two conditions. The student who knows that he is working in a department actively emphasizing new methods and striving to develop new truths, knows that his instruction is presented on the same basis, and thus receives that stimulus and inspiration which insures his approaching clinical medicine with a proper appreciation of the scientific method. The student under circumstances of the second order has no incentive other than that of acquiring a knowledge sufficient to allow him to pass an examination.

This last condition of affairs we will, however, have with us until

appointive bodies realize that "it is a disgrace to a university to appoint a man as professor chiefly because he is a 'good teacher'; such a man may be a good teacher, but only investigators can give university instruction" (Minot).

I have seen somewhere, in an essay on Russian politics, if I remember rightly, a quotation from the Greek, to the effect that the character of a city is determined by the character of the men whom it crowns. So, likewise, is the educational policy of a university reflected in the character of the teachers it appoints.

I have often thought that our departments of biologic chemistry and experimental pharmacology forcibly illustrate the importance of the investigator as a teacher. With few exceptions, they are manned by active investigators and from the point of view of medical pedagogy are most satisfactory. They represent, as now organized, the most recently developed of the medical sciences, and have emerged directly from the fields of most active investigation in physiology and chemistry. They have no vast theoretical literature back of them, no traditions as to methods of teaching, but they have established their own methods on the basis of observation and experiment. "Medical chemistry" and "therapeutics" were once taught by "good teachers," but the investigator in physiology and chemistry has transformed them into sciences of university rank to which the former narrow terminology no longer applies.

These three factors—authoritative control to arrange correlation, cooperation by department heads, and the appointment of teachers who are also investigators—are fundamental in the application of the methods of experimental medicine to proper teaching. Two other factors, however, are concerned. These are closely related. One is the question of electives and the other the question of actual research by the student. The first, necessary for any proper attempt at correlation, is obligatory if the student is to work independently, even in a small way, as an investigator. As the advisability of giving the student the latter opportunity is still a disputed point, however, it may be discussed first. As every teacher knows, each class contains a considerable number of men who desire to pursue, to a greater extent than the conventional course allows, work on certain subjects or by special methods, or less frequently, perhaps, they desire, and are usually well qualified to undertake, minor investigative work. To the former, as well as to the

latter, any effort spent in work beyond that given the entire class becomes, necessarily for them, the acquirement of the methods of research, and as this means a knowledge of the exact, painstaking methods by which the realms of the unknown are explored it is an exercise which prepares the student for the daily routine research work of the physician who truly practises his profession. As a training for future work its value is definitely known and the increased zest and enthusiasm exhibited towards their medical work by men who have had this opportunity are always evident. Pedagogically, therefore, it would seem advisable that every student should have the opportunity for minor research, in order that he may become acquainted at first hand with the careful methods of experimental medicine. The bearing of the tangible results of his work on the subject investigated is a matter of little or no importance; the vital thing is the increased power which he himself acquires. If the student is to have such opportunity the elective system is necessary. This principle has been recognized by those in control of this school, and you have in your fourth year the first attempt to arrange wisely for research work as well as for concentration of work on related subjects. It has also been recognized by the Johns Hopkins Medical School, where, however, some elective work is placed in each year, instead of being limited to one year. It is too early to say which of these two systems is the better, but the matter is in safe hands and we may await the ultimate decision on this point with the knowledge that electives, wisely arranged and wisely chosen, are essential to proper medical education and must eventually be adopted by all schools of the first rank.

So much for the use of the experimental method in the two laboratory years. This method, if it has any special significance, should bear fruit in the third and fourth years, the periods devoted to clinical teaching. Are our clinical departments so organized that they are prepared to aid the student in his development along scientific lines? A few are, but for the most part the clinician returns the student to the methods of the lecture-room and the demonstration and gives him little opportunity to develop his powers of personal observation. The discussion of this phase of teaching may be limited to the department of medicine, as contrasted with surgery and the specialties, though what is said of medicine applies equally to other clinical branches. The department of medicine should be the great glory of the medical school,

do and how to do it, but not what he is to find; in other words, a continuance of instruction in methods, leaving the matter of deduction in large part to the student himself. This is the training by which in his hospital days or in private practise every capable physician has obtained his knowledge of medicine, and it is a training which every medical school ambitious to teach medicine properly should anticipate in the fourth year of its curriculum. This means, as has been frequently stated by the advocates of this method, that the hospital and the dispensary are to be regarded as the laboratories of clinical medicine and that clinical medicine should be taught by the scientific method common to all laboratories. That this method can be successfully carried out is shown by the clinical clerk system of the English hospitals and by a few of our own schools. These latter have done a good work in demonstrating the possibility of applying the method to large classes, thus removing one of the chief objections to its use. As to the actual working of this method I can not do better than to quote, with slight changes, from the Carnegie Report on Medical Education:

> The fourth year is spent in the hospital. . . . The class is broken up into small groups. Each student gets by assignment a succession of cases, for a full report on each of which he is responsible; he must take the history, conduct the physical examination, do the microscopic and other clinical laboratory work, propound diagnosis, and suggest the treatment. For this purpose he has easy access to the hospital wards. His "beds" are under his continuous observation from the day his "patient" is admitted until the day of discharge; or in event of death, he and the physician ultimately responsible for steps taken in treatment repair with others to the autopsy-room to bring their knowledge to the test. . . . Meanwhile the clinical teaching has closely followed the development of the case. At brief and regular intervals its status is reviewed. All other members of his group, and the patient too, are at hand when the student presents his report, which forms part of the permanent record of the case. At every point he has been checked up; the instructor in charge of the clinical laboratory inspects and verifies his work there; the clinical instructor here. Subject to this control, complete, of course, from the standpoint of treatment followed, the student is a physician practising the technic which, it is hoped, may become his fixed professional habit; learning through experience, as indeed he will continue to learn—long after he has left school—a controlled, systematized, criticized experience; not the blundering, helpless "experience" on which the didactically or demonstratively taught student of medicine has hitherto relied for a slow and costly initiation into the art of medicine.

If with this is combined the similar study of a constantly changing dispensary service, the student has an opportunity to study variety and to perfect methods of diagnosis, thus supplementing the more prolonged observations in the ward.

The conduct of such a course brings up several of the problems now attracting the attention of all who are interested in medical education. It can not, it is evident, be successfully given in a hospital not an integral part of the university. This is the experience of all schools which have attempted it in hospitals with which they are affiliated but in which they have no authority. Questions of authority over patients, of equipment for teaching, of laboratory space for clinical study, all indicate that the first essential is the possession or control by the school of its own hospital. This allows an easy solution of all problems: Continuous service and freedom in the appointment of clinical teachers come as a matter of course. Teaching and investigation can be carried on without interruption. The student becomes a part of the hospital routine and is not an onlooker with limited privileges. The laboratory departments of the first and second years unite to aid the work of the clinicians in the hospital. Clinical teachers may be promoted, if deserving, or may be called from any part of the country, or from abroad; the choice no longer depends on local hospital appointments or on selfish interests and friendships of local consultants, but on fitness, eminence and skill.

Teachers may be appointed on a university basis, devoting all or most of their time to the care of the patients, to teaching and to investigation. The heads of the departments of internal medicine and surgery certainly should be so appointed. Under such circumstances these men with their staffs could control a large body of students working relatively independently among the patients in the wards and in the special laboratories in or near the wards. In these clinical laboratories every student should have his own desk and outfit for microscopic, chemical and other methods of examination. Not merely apparatus for the simpler tests should be supplied, but as well every facility for prolonged bacteriologic examination, animal inoculation and detailed chemical and physiologic study.

Such a plan insures diagnostic ability and therapeutic skill by training the powers of direct observation as well as by instructing in the methods of indirect observation through the use of instruments of precision and the procedures of the chemical and biologic laboratories. The experimental method emphasized in the laboratory years is thus continued through the clinical years. Laboratory procedures naturally fall into their proper place in relation to the methods of direct observation, and as the student approaches each new disease in the spirit

of the investigator and not as an onlooker he gains a point of view which can not fail to have an important bearing on his work as a practising physician.

Aside from the question of expense, the only argument which has been raised against this plan is that the patient might suffer. This is denied by all who have had experience in a teaching hospital, and on this point we have the published statements of a well-known surgeon, the head of a training school for nurses and of the committee appointed to investigate the relations between the hospitals and the medical schools of London. All agree that the care of the patient and the routine of hospital work is on a higher level in teaching than in non-teaching hospitals; and these opinions take no account of the advantage to the public at large of producing better physicians.

Whatever has been said about the instruction in internal medicine applies with equal force to surgery, pediatrics and obstetrics. These four subjects constitute the backbone of medical knowledge, and the last three deserve a word of comment. Pediatrics, frequently served by special hospitals, is amenable to the same individual teaching as internal medicine, and because of its peculiar importance should have a more prominent place in the medical curriculum than is usually assigned it. Obstetrics presents special difficulties because of the infrequence of maternity wards and also on account of the wide scattering of the out-patient service, but these difficulties are not insurmountable.

Surgery, from the point of view of diagnosis and the care and treatment of the minor common lesions and injuries, may be taught by the same methods as those outlined for internal medicine, and, most important of all, the frequent lectures and large operative clinics from which the students gain little or nothing, should be replaced by courses in experimental and veterinary surgery, offering an opportunity for detailed training in the administration of anesthetics, in asepsis and antisepsis, in the preparation before and the care after operation, and above all for the study of repair of wounds and their treatment.

Much of surgery and of the various specialties should be given as elective courses, in the manner adopted by this school, or as postgraduate work. No physician needs to know, or can know, all the specialties in detail, and only a relatively small number become operating surgeons. Those that do specialize, do so only after a thorough postgraduate training. The great bulk of men who practise medicine should have

as thorough a training in internal medicine and closely allied branches, such as pediatrics and neurology, as it is possible to give. With this, in the obligatory course should go a general knowledge of the principles of surgical diagnosis and a certain minimum knowledge of the specialties; a knowledge sufficient to meet emergencies and to know when to seek assistance of the expert in this or that specialty. A curriculum based on this plan would free a large amount of time for the individual work in the department of medicine and closely related branches.

The faults of the present system, which gives undue prominence to surgery and the specialties at the expense of internal medicine, may be illustrated by determining in a curriculum the number of units given to each subject, on the basis of 100 units for the entire four-year course. Thus, in one of our most prominent schools, with excellent clinical facilities, we find, according to last year's catalogue, anatomy, surgery and medicine represented by 18, 15.5 and 14 units, respectively. The nearest approach to these figures is pathology with 9.5 units. If the units of the courses in orthopedic surgery, genito-urinary surgery and surgical anatomy be added to surgery, the total for that subject becomes 18.35 units, while the addition to medicine of physical diagnosis and clinical microscopy raises the units of this subject to only 18. Certainly this proportion overestimates the importance of anatomy and surgery in relation to internal medicine. Other curious relations seen are pediatrics with 1 unit, while dermatology has 1.5; obstetrics 3 units, while gynecology has 2, and neurology 2.75, while mental diseases have only 0.25 of a unit. These subjects are taught in large part by lectures. The figures given are fairly representative of most schools which do not offer electives and indicate the ill-advised way in which the specialties are presented to the student. An arrangement by which much of the time given to lectures in anatomy and surgery and the specialties could be devoted to practical hospital work in internal medicine and well-selected elective courses would give a better balanced course without diminishing the really valuable work of each subject.

One or two other matters of importance in the teaching of clinical medicine may be briefly mentioned here. One of these is the advisability of offering small groups of students the opportunity of studying, as an elective, the diseases of one organ, or of related organs, from every point of view. I have been much interested in such a course given last year by Dr. W. T. Longcope at the University of Pennsylvania and

known as a course in "medical correlation." During one year a group of six students studied the diseases of the heart from the clinical, the pathologic, the experimental and the therapeutic point of view. All the methods of clinical observation were brought to bear on the cases in the wards of the hospital; gross and microscopic preparations illustrating the pathology were examined; the normal physiology of the heart was studied in animals by the methods of physical diagnosis and of graphic registration, and finally these were used also in the observation of lesions produced experimentally. The relation of various diseases of the heart to diseases of the lungs, liver, kidney and other organs and tissues was thoroughly covered and the effect of treatment on patients in the wards and experimentally produced lesions in animals observed. Of the value of such a course, even though it be given only to a small group, there can be no doubt. Its value, however, lay in the point of view which Dr. Longcope, as a widely trained clinician, pathologist and investigator, brought to bear on the problems presented. Of similar importance are the courses in pathologic physiology formerly given by Dr. MacCallum in Baltimore.

Another matter concerns departments in the medical school known as research departments and variously described as departments of experimental pathology, experimental medicine or research medicine. The title matters little, but the plan of the department should be broad enough to care for the problems of clinical medicine, and for this reason the word "medicine" should appear in the title rather than the word "pathology." Such a department should keep in close touch with the department of clinical medicine, and should supplement the facilities of the various hospital laboratories, but, nevertheless, should also work in cooperation with the fundamental laboratory sciences in order to insure a realization of the greatest good to the school. The head of the department should be a man familiar with the problems of clinical medicine, trained preferably as a pathologist, and with sufficient knowledge of the possibilities of physiology and chemistry to apply the methods of these subjects to clinical problems. I say preferably a pathologist because the pathologist is more apt to combine clinical training with a knowledge of pathology, bacteriology and the principles of immunity than is the physiologist, chemist or pharmacologist, though any one of the latter might well head such a department. Certain it is that whatever his own training may have been, the director should, with his

assistants, be able to utilize in the work of the department the methods of physiology, chemistry and experimental pathology. In other words, he should have a department capable of attacking a problem in medicine from any or all sides, including that of experimental therapeutics; and in order to make the work effective, he should have the use of beds in the university hospital.

The work of this department should be the investigation of clinical problems, and not of academic problems of pathology, chemistry, physiology, etc. The latter can still be carried on in the departmental laboratories, which have always followed academic lines, and, in truth, are forcing, through their neglect of clinical problems, the establishment of the type of department described. General practitioners, clinical assistants in the school, and even those at the head of clinical departments are constantly meeting problems which demand solution, but find no adequate opportunity to investigate them in departments as now constituted. Indeed, if not turned away at once, they are sent from department to department, seldom finding either encouragement for work or the equipment necessary for a problem which has more than one technical side. Such men would find a place in the department suggested and would constitute an enthusiastic working staff which should be exceedingly productive and should influence for good the clinical teaching. Indeed, one might find such a department an important factor in the training of clinical teachers of the investigative type.

Another function of this department should be undergraduate instruction to fourth-year men taking research work in clinical medicine as an elective, and also post-graduate instruction for those desiring training in the methods of experimental medicine as the basis for a career as teacher or investigator.

I may be over-enthusiastic about this matter, but I believe that departments such as I have outlined are a necessary part of every large university medical school, and must be developed eventually through the combined efforts of the pathologist and the clinician, who have naturally a greater interest in the problems of disease than have the men of other departments and who must have an investigative department devoted to their common interests.

In this discussion I have approached the subject from the side of the teacher, and if I have emphasized the faults of our system it is because, as you have probably surmised, I have desired to point out

what is best for the student in that training which leads to the practise of medicine. The practise of medicine has developed out of empiricism by the application of the methods of its tributary sciences and whatever is definitely known and understood in medicine can be traced to the application of the experimental method. You, therefore, as students of medicine, must consider the fundamental medical sciences, not as a mere accumulation of facts, but as an opportunity for training in principles and methods which you can apply to the specific problems of clinical medicine, and then later, when your days as student and interne are over, you should, if you follow this course, have acquired a power in the use of the methods of experimental medicine which will be of value to you in your every-day work. You will have an interest not only in the investigation of the problems of general practise by the usual clinical methods, but you will find yourself turning to the methods of the laboratory, and this may result not only to your own advantage, but to the advantage of the science of medicine in general. In brief, you will be doing your share to establish a science of clinical medicine on which only can the practise of medicine be properly based. That such activities on the part of the clinician are now generally recognized as desirable is shown very clearly by the formation of new societies to encourage and promote clinical research. The Association for the Advancement of Clinical Investigation, for example, has brought together a large group of men, mainly of the younger set, interested in investigation in internal medicine. Likewise, the Interurban Clinical Club has stimulated, as will doubtless its junior counterpart now being organized, an interest in exact investigation in medicine which is prophetic of a great change not only in the practise of medicine, but in our methods of teaching. I can wish each of you no greater honor than membership in the Association for the Advancement of Clinical Investigation.

In recommending to you that, as practitioners, you keep always the point of view of the investigator, I realize fully that as you go out among so-called "practical" doctors you will find many who sneer at what they term the "scientific" doctor. This view, of which we hear less and less each year, is a survival of the opinion commonly held prior to the development of the sciences of bacteriology and physiologic chemistry, which sciences, by their practical applications to every-day medicine, have perhaps done more to dispel it than is usually realized.

I may quote from the words of a past and present teacher in this school to illustrate this change in attitude. Fortunately, for purposes of comparison, both represent the department of anatomy. One, Oliver Wendell Holmes, in an introductory lecture to the class of 1867, discussed the question of whether or not the young physician should take an active interest in investigation in medicine. He expressed his disapproval in the words "take down your sign, or never put it up," thus implying that at that time practise and investigation were considered incompatible. The same implication we find, also, in his frequently quoted phrase, if a man "has not plenty of good common sense, the more science he has, the worse for the patient." Thirty years later, we find your present professor of comparative anatomy summing the matter up in the statement: "So far as I know, the most important difference between a 'practical' doctor and the truly scientific is that the patients of the former are more likely to die."

You may not be aware of it, but this change in attitude, as seen not only in this school, but throughout the country, may be traced to the efforts of one man, the late Henry Pickering Bowditch, who, by establishing in the seventies a modern laboratory of physiology at Harvard, initiated those facilities for instruction and research on which our present standards rest. By his own work, in his laboratory and out of it, by printed and spoken word, by suggestion and kindly criticism, he labored for one ideal in medicine, the training of the scientific physician. Indeed, I do not think it an exaggeration to say that these magnificently equipped buildings in which you are receiving your medical training are the culmination of this ideal. Dr. Bowditch believed in the scientific rather than the so-called "practical" physician, and to this belief, to his labors and his influence, is due the most valuable part of the education you are now receiving. You owe him, as does this school, and as does also the entire medical profession and the cause of medical education in America, a great debt; this in so far as it concerns you, you can repay, in part, at least, by so utilizing your training as to advance the cause of scientific medicine and thus continue the good work which Dr. Bowditch began. Memorials he will have in abundance; this school in the fulfilment of his conception of its development the greatest of them all, but I am sure no tribute would please him more than that offered by its graduates in an earnest desire to make real his vision of the scientifically trained physician.

As to the views which I have expressed, I wish to make it clear that I do not refer to the training of the investigator, be he physician or otherwise, usually described as a genius. My suggestions are offered as a possible means of adding to the number of those individuals, of whom we still have too few, who, slowly, steadily and safely advance established lines of research or of practise by adding a little here and strengthening a little there in the gradual change from an empiric to a scientific medicine.

Moreover, I claim no great originality, but present my conclusions as a fairly accurate statement of the results of a close study of our methods of teaching, and if I have magnified the faults of our system, it is not from a desire to be hypercritical, but with the hope that closer attention to such faults may hasten improvement.

I have read recently an address by President MacLaurin in which he discusses some of the factors which in the course of fifty years have placed the Massachusetts Institute of Technology in its present commanding position. Two of these factors are worthy of the earnest consideration of the trustees and teachers of our medical schools. The first President MacLaurin presents as follows: "There has never been any uncertainty or indefiniteness as to what the institute is aiming at in its scheme of education"; the second embodies the idea that the success of the educational policy of the institute has been due to the fact that the emphasis has been laid on the "*method*" and *spirit* of science rather than on *subject*, and that the "*method by doing*" or "*do it yourself*" idea has been systematically applied. We need, in medicine, a greater appreciation of both these factors by our trustees as well as by our teachers; of educational policy by the former, of educational method by the latter.

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The following list of addresses is appended as representing some of the arguments in favor of the use of the experimental method in the teaching of medicine. I freely acknowledge the use of much of the material and many of the suggestions therein contained.

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CHANCE AND THE PREPARED MIND[1]

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"In the fields of observation chance favors only the mind which is prepared."—Pasteur.

It was at the opening of the Faculté des Sciences at Lille on December 7, 1854, that Pasteur, only thirty-two years of age at the time, but already professor and dean of the faculty, uttered these words in upholding, in his inaugural address, the value, on the one hand, of practical laboratory instruction as an aid to the solution of industrial problems, and, on the other, the importance of investigation in pure science, even though the resulting discoveries might have no immediate application. The point of view may have been novel when it was uttered, but in the sixty years that have elapsed how familiar it has become. How closely it approximates the ideals of those who are striving to improve the conditions of medical education and of medical research in our own day and country. What better argument can the most ardent advocate of detailed practical instruction in laboratory or hospital (medical training at first hand) present, than that which Pasteur offered in 1854. He asks:

> Where will you find a young man whose curiosity and interest will not immediately be awakened when you put into his hands a potato, when with that potato he may produce sugar, with that sugar, alcohol, with that alcohol, æther and vinegar? Where is he that will not be happy to tell his family in the evening that he has just been working out an electric telegraph? And, gentlemen, be convinced of this, such studies are seldom, if ever, forgotten. It is somewhat as if geography were to be taught by traveling; such geography is remembered because one has seen the places. In the same way your sons will not forget what the air we breathe contains when they have once analyzed it, when in their hands and under their eyes the admirable properties of its elements have been resolved.[1a]

[1] An address given under the auspices of the Alpha Omega Alpha Honorary Medical Fraternity, Syracuse University. Published in *Science*, June 21, 1912.

[1a] Vallery-Radot, "The Life of Pasteur," McClure, Phillips & Co., New York, 1902.

Pasteur was a chemist, a physical chemist, if you will, and his illustrations were drawn from the realms of physics and chemistry, but if one substitutes for "electric telegraph" any piece of apparatus now in use in a medical laboratory or a hospital, the principle of the better type of modern medical instruction is embodied in his argument. He was talking to those who, after two years of practical and theoretical study, were to enter industrial careers as overseers and foremen in factories, foundries and distilleries. But neither time nor circumstance fundamentally alters the applicableness of his observations. After sixty years we may still urge his thought as the soundest of principles in the better education of men and women who are ultimately intended to enter careers as our overseers in matters of health and disease and as the foremen of public hygiene. Have our present-day medical schools succeeded in bringing to the training of their students the same practical and scientific thoroughness which Pasteur demanded for students in the industrial sciences and which students of the latter sciences now procure? If not, where lies the fault; in the college or the medical school, in the state or the public? Or are all more or less to blame? These questions will be discussed in due time, but first let us turn to Pasteur's other proposition, investigation for its own sake. After stating his wish to be directly useful, personally and through his laboratory, to the industries of Lille, he says:

> Without theory, practise is but routine borne of habit. Theory alone can bring forth and develop the spirit of invention. It is to you specially that it will belong not to share the opinion of those narrow minds who disdain everything in science which has not immediate application. You know Franklin's charming saying? He was witnessing the first demonstration of a purely scientific discovery, and people round him said: "But what is the use of it?" Franklin answered them: "What is the use of a new-born child?"
>
> Do you know when this electric telegraph, one of the most marvelous applications of modern science, first saw the light? It was in the memorable year 1822; Oersted, a Danish physicist, held in his hands a piece of copper wire, joined by its extremities to the two poles of a Volta pile. On his table was a magnetized needle on its pivot, and he suddenly saw (by chance you will say, but chance favors only the mind which is prepared) the needle move and take up a position quite different from the one assigned to it by terrestrial magnetism. A wire carrying an electric current deviated a magnetized needle from its position! That, gentlemen, was the birth of the modern telegraph. Franklin's interlocutor might well have said when the needle moved: "But what is the use of that?" And yet that discovery was barely twenty years old when it produced by its application the almost supernatural effects of the electric telegraph!

This, gentlemen, may seem trite to you, for it is an argument oft repeated, but its significance, as far as medicine is concerned, lies in the fact that at the time Pasteur made these statements modern medical investigation was just beginning. The celebrated physiological institute at Berlin had been in existence only sixteen years; Schwann, following Schleiden, had elaborated the cell doctrine only fifteen years before and anesthesia had been practised for only six years. Claude Bernard was in the midst (1850–60) of his important discoveries concerning the pancreatic juice, the glycogenic function of the liver and the vasomotor system; three years were to pass before Virchow established (1855) the first pathological institute and as many again before this great master was to announce the doctrine of cellular pathology; and finally, it was thirteen years before Lister's first publication concerning the antiseptic treatment of wounds.

In all these activities and those which followed, the ideal of seeking for the truth no matter where it might lead—the ideal of pure science —was the secret of that wonderful progress which medicine has made in the last seventy-five years.

Now, however, it is time to return to our text, "In the fields of observation, chance favors only the mind which is prepared." What did Pasteur mean by "chance"? His meaning is very evident in his example of Oersted and the magnetized needle. The mind which is trained to observe the details of natural phenomena, and to reason concerning the bearing of known laws on such phenomena, is the "prepared mind," that is to say, it is a class of mind which, because it is endowed with a peculiar faculty, best described as scientific imagination —grasps the significance of a new observation, or of a variation from a known sequence of events, and thus establishes a new law or invents a new practical procedure. To no man perhaps is this adage of Pasteur more applicable than to himself. It was his work in chemistry and his studies in crystallography that gave him the "prepared mind" which correctly interpreted the significance of the chance observation that the presence of a vegetable mould, the *Penicilium glaucum,* in solutions of salts of the tartaric acids, changed an optically inactive to an optically active fluid. He grasped at once the true interpretation of this reaction. The disappearance of the dextro-tartaric acid, the permanence of the levo-tartaric acid, could be explained only by the assumption that the ferments of this particular fermentation "feed

more readily on the right than on the left molecules." So did "chance" direct the "prepared mind" to those fundamental observations which established our present-day principles of fermentation, and which, as the result of work on alcoholic, acetic, lactic and butyric fermentation, led to Pasteur's final dictum:

The chemical act of fermentation is essentially a correlative phenomenon of a vital act beginning and ending with it.

It was but a short step for the mind thoroughly familiar with the principles of fermentation to embrace the opportunity offered by the study of the etiology of the infectious diseases, and so through all his work, as that in connection with the silk-worm problem, vaccination against chicken cholera and anthrax, and the treatment of rabies, the "prepared mind" of the great master saw and appreciated the significance of every observation and every opportunity which presented itself.

Many other examples might be presented, as Semmelweis and his observations on the high mortality from puerperal sepsis among those under the care of students fresh from the dissecting and autopsy room and the low mortality among patients under other supervision. So also Lister and his antisepsis; and best of all, perhaps, for purposes of illustration, the sequence of Ehrlich's discoveries. We are told that in his student days Ehrlich was interested above all other things in the study of chemical affinities and worked incessantly with the new anilin dyes. Indeed the story goes that so engrossed was Ehrlich in his work that neglect of the required studies gave rise to some question concerning his right to receive his degree. The situation as described by Christian A. Herter[2] was as follows:

Although at this time Ehrlich was especially under the direction of the anatomist Waldeyer, he rapidly developed a capacity for chemistry which was a surprise both to himself and to the chemist, Adolf von Baeyer, whose lectures had been systematically cut by the gifted but unconventional student. For unconventional he then was, and ever has been, neglecting what he did not like and throwing himself with fervor and intense energy into the solution of the themes that attracted him. From the outset it was clear that Ehrlich would make a career as an experimental investigator. Much of the time he was supposed to spend in taking the usual medical courses he devoted to experiment. When Robert Koch was shown through the laboratory at Breslau by one of the professors, his attention was called to a young student working at a desk covered with bottles of dyestuffs. "There is our little Ehrlich," said the professor; "he is a first-rate stainer of tissues, but he will never pass his examinations."

[2] Herter, C. A., "Imagination and Idealism in the Medical Sciences," *Jour. Am. Med. Assoc.*, LIV., p. 423, 1910.

The prediction about the examinations came perilously near fulfillment; Ehrlich made bad flunks and it is hinted that he never would have received his degree had he not made a discovery—namely, the existence of the peculiar type of leucocyte which is known to us as the "plasma-cell." The faculty reasoned that it would be improper to keep so promising and original a worker indefinitely in an undergraduate position, and it is suspected that they mitigated the rigor of the examinations in order to relieve their own embarrassment.

These early studies were doubtless responsible for what must be considered as the main theme of all Ehrlich's work—the specific affinity which exists between specific living cells and specific chemical substances. The "prepared mind" is evident in his study of the cells of the blood, of the selective action of methylene blue on the nervous system, of the use of the same dye in the study of oxidations and reductions occurring in tissues, of his studies in immunity, of the specific treatment of protozoan disease, and also according to recent reports in his application of the same principle to the study of cancer. Manson's studies of the relation of the mosquito to filariasis, which led to Ross's study of the transmission of malaria by the same insect, is another example of the "prepared mind" properly interpreting a chance observation. Sometimes such discoveries are referred to as the result of scientific imagination—and it truly is this—but doubtless the same "chance" came to many besides Pasteur, Ehrlich, Laveran, Koch, Theobald Smith, Manson, Ross and Reed; it was the training of these individuals, the mind prepared to utilize scientific imagination, that enabled them to grasp the opportunity offered by "chance" observation. Every one familiar with the history of investigation in medicine knows that before Harvey, men studied the circulation; that before Pasteur, bacteria were seen in diseased conditions; before Lister, the effect of cleanliness upon surgical mortality had been noticed; before Laveran, the plasmodium of malaria had been seen; before Manson and Ross, the possibility of the transmission of malaria by the mosquito had been discussed. Truly,

remarkable achievements are never unique occurrences in nature. Even the greatest men rest on the shoulders of a large multitude of smaller ones who have preceded them, and epochal discoveries emerge out of a period of intellectual restlessness that affects many minds.[8]

But of these minds, it is that one which is "prepared," trained in the methods of observation, therefore possessing the priceless quality of

[8] Flexner, S., "The Biological Basis of Specific Therapy," Ether Day address at the Massachusetts General Hospital, October 16, 1911.

scientific imagination, which sees the proper block which when placed exactly where it belongs completes the edifice of a perfect theory, and thus establishes a new landmark for future progress.

But what, you ask, has all this to do with the training of the physician? How does it apply to medical education? We admit the value of these qualities in the investigator, but of what value are they to the man seeking the education necessary to practise medicine? Let me repeat Pasteur's adage—"In the fields of observation, chance favors only the mind which is prepared." Certainly, all will agree that medicine is largely an observational science and one of the "fields of observation" of Pasteur's definition. Medicine may not be all science, but clinical medicine in its most essential phase—diagnosis—is essentially a science of observation, either of direct observation by the use of the unaided senses or indirect by the use of instruments of precision, or by chemical, biological or other tests. Therefore, whatever force or whatever lesson this adage may carry applies to medicine. And now as to the interpretation of "chance." I have not been able to obtain the original French of Pasteur, but from his parenthetical phrase in connection with the discussion of the telegraph it is clear that he meant exactly what the translator has given us, chance or opportunity in the sense of an unexpected observation or an accidental occurrence. Pasteur's idea was that such unexpected or accidental occurrences would not arrest the attention of the poorly prepared mind, but that the well-prepared mind, trained to observe, to think and to compare, would grasp the significance of the unexpected, the unusual or occasional, put the observation to the test, by experiment or control, and arrive at the correct conclusion. Is not this a matter of daily occurrence in clinical medicine? Does not chance (opportunity some would call it) and care in details play an important part in diagnosis? Is not every ailment the physician sees a puzzle? every diagnosis, if correct, a solution of that puzzle? One speaks of the man who solves the puzzle which has baffled half a dozen other men as a keen or accurate diagnostician. They imply that he has an added power, or that his skill is the result of wider experience, forgetting they may have seen as many individuals with the malady as had the consultant, and perhaps totally ignorant of the fact that his diagnosis was possibly based on a chance observation which meant more to his trained imagination than it did to minds unaccustomed to weigh the significance of details. Every

clinician of experience can give examples of the importance of chance and imagination in actual diagnosis. An interesting illustration is that

of the two students who reported on the same patient in competition for a clinical prize. The patient presented, among other symptoms, a remarkable discoloration of a certain area of skin, and the first student described this discoloration with the most careful minuteness. He measured it in different directions and drew a rough sketch of its general outline. The second observed the phenomenon with equal care, but he exercised his imagination and formed a hypothesis which he proceeded to put to the test. He asked a nurse for a wet towel, with which he wiped the discoloration away. It is evident that the faculty which he thus brought to bear on the problem before him would be likely to stand him in good stead in relation to many others of a more complicated character; and that his exercise of the art of diagnosis would be practically immune from the errors incidental to the habit of taking all appearances at their face value. Imagination at once points to the possibility of more than one explanation of any given occurrence, or alleged occurrence, and compels inquiry as to the existence of probable causes beyond the particular one which may at first sight appear to have been in operation.[4]

From what has been said, then, it should be evident that it is the first duty of a medical school to prepare men properly for the practise of medicine (and the most ardent advocate of research in the university will not deny that this is the first duty). If so, what are the conditions to be fulfilled to ensure the "prepared mind" of Pasteur's adage?

The Preliminary Education of the indivdual is the first and in many ways the most important consideration. I know it is bringing coals to Newcastle to discuss this question before the students and faculty of Syracuse University, for you have been among the first to recognize the value of two years' college work which shall include physics, chemistry and biology. Still this principle is not generally recognized. Many of those in positions of authority in our medical schools, while loudly proclaiming the right of medicine to a place among the sciences and indeed characterizing it as the "Mother of the Sciences," deny that a scientific education is a prerequisite to medicine. True, the opposition is frequently due to a realization of the awkward financial position in which an administration might be placed if students' fees diminished. Frequently also it is due to the claims of those who hold that a greater cultural value lies in following the humanistic rather than the scientific school of thought. Naturally, there is also the "poor boy cry" and the closely associated cry that outlying districts will not be properly cared for if the cost of medical

[4] "Imagination in Medical Research," *Lancet*, 1912, CLXXXII., 179.

education is increased. The "poor boy" argument may be dismissed at once, for those who have had experience in teaching medicine know that the boy, poor or otherwise, who knows what he wants in the way of an education, gets that education in spite of all difficulties, and as a rule, if he has to work for it, is keen enough to get the best that is to be had. Such men will "come through" despite all apparent barriers in the way of higher preliminary requirements; if the indifferent "poor boy" fails, lacking ambition and a clear conception of what he wants, so much in favor of the higher requirements.

As to the outlying districts, we need have no fear as long as the ratio of physicians to population is 1 to 586[5] and the use of the automobile is increasing. If the ratio should change greatly, which does not seem likely, for only two states[6] (North and South Carolina) have a ratio of less than 1 to 1,000, the matter then becomes one for state regulation, for, as the report of the Carnegie Foundation has shown, we have enough physicians, but the difficulty lies in the tendency of physicians to seek the larger civic centers.

With the discussion of the cultural value of humanistic as compared with scientific studies we are not concerned. It is sufficient that in a university medical school a man can not properly study modern medicine without that knowledge which comes from a familiarity with laboratory work in physics, chemistry and biology. The value of biological training for those interested in practical medicine was emphasized by Huxley many years ago, and that in physics and chemistry has recently been emphasized by Friedrich Müller[7] in describing, for the benefit of the English Commission, the training of the German medical student.

> During his first and second year,[8] the medical student attends lectures and does laboratory work in physics, chemistry, botany and zoology in the philosophical faculty, and he has the opportunity of widening his views by listening to lectures on philosophical or historical subjects. His teachers and laboratories are the same as for the students of the natural sciences, and this is right, because there is no such thing as special medical physics or chemistry; the physician requires a broad knowledge of the general sciences of physics and chemistry.

It is most important to have this statement of Müller's at a time

[5] Flexner, A., "Medical Education in the United States and Canada," Bull. No. 4 of the Carnegie Foundation for the Advancement of Teaching, 1910.

[6] *American Medical Association Bulletin*, 1910, V., 278.

[7] Müller, F., "Memorandum on Medical Education Submitted to the Royal Commission on University Education in London."

[8] The German student seldom takes his state examination until the end of five and a half years' work (Müller).

when an effort is being made to place physics, chemistry and biology in the medical curriculum. With or without a fifth year it is a dangerous policy. The experience of one school in this regard is enlightening. During the period of change from a high-school to a two-year college requirement, conditioned men were cared for by allowing time in the first half of the first year to make up conditions. The procedure took eighteen hours a week from the time which should have been devoted to purely medical studies. In such an emergency as that of a change of policy, this was perhaps justifiable, but what university school with a four-year course can afford this arrangement as a permanent policy? And if we are to have a fifth year, progress demands that it should be a clinical or hospital year, and not a preliminary year for work which belongs to the college. The modern curriculum of a first-grade medical school demands a student's full time and attention and no amount of general culture can make up for absence of prerequisites in physics, chemistry and biology. The school which allows mixed requirements, or low requirements or conditions, does so at the expense of efficiency; the good men suffer on account of the slow progress of the poorly trained; the inefficiency of the teaching under such circumstances becomes noised about, and it comes to pass that the best-trained men go to schools which take only their kind, and thus eventually low standards react on the school allowing them.

But this is not all. Another factor, the state, is beginning to play an important part in determining the conditions prerequisite to medical education. Five[9] states have passed laws demanding that for license to practise medicine an applicant must have had two years of college work as a minimum requirement, and four[10] demand one year. This, we must admit, is only the beginning. As state after state adopts the same ruling, schools not demanding such preparatory study must see the territory open to their graduates (and therefore the territory from which they draw students) gradually narrowed. Certainly, today, no school, and certainly no university school, can face with equanimity this discrimination; and "disappointed indeed will be that student who, after having spent a large amount of time and money, finds on graduation that his diploma is not recognized in a large number of states."[11]

[9] Colorado, Indiana, Iowa, Minnesota and North Dakota.

[10] Connecticut, Kansas, South Dakota and Utah.

[11] *Jour. Am. Med. Assoc.*, LVII., p. 1138, 1911; LVIII., p. 487, 1912.

Methods of Teaching.—Within the medical school itself the matter of educational policy is clear. Here there can be only one procedure, the constant and consistent employment of the "do it yourself" or "learn by doing" method; the student must be taught to observe, experiment, reason and act for himself. This, I know, is trite, but the conditions out of which our present methods of medical education have emerged demand that this point of view be continually emphasized. It is not long since the day of the two and three year course and the imparting to undergraduates of all medical instruction, outside of anatomy and inorganic chemistry, by lecture. The development of the laboratory branches—histology, pathology, bacteriology, physiological chemistry and pharmacology—and the cheapening of physiological apparatus, have given a new turn to medical teaching, that of active participation by the student. But still even in these branches the lecture still persists in most schools and frequently is so magnified in connection with the laboratory instruction as to make it appear in the eyes of the student as the most essential part of the course. The advance in methods and means of practical laboratory instruction—that is, the visible machinery for developing the principle of teaching by actual observation and experiment—would seem in some schools to be an equipment for advertising purposes only. One does not have to go outside the group of our so-called "big" schools to find a department of pathology, abundantly equipped with apparatus and a wealth of pathologic material, offering five lectures a week; and one may find an elaborately equipped student's laboratory of physiology manned by assistants while the head of the department fulfills his duty to his class with three or four lectures a week; and likewise, in the clinical branches, few men have had the courage to do away with frequent and voluminous lectures. Even schools controlling a large hospital, and sometimes several, and thus having an abundance of clinical material, do the bulk of their teaching by the formal lecture and the amphitheater clinic. The ward class and the clinical-clerk system gain ground but slowly. The reason for this attitude is easily found. The lecture is the easiest form of teaching, and the average teacher, whether he be the laboratory man overburdened by executive detail and handicapped by lack of assistants, or the clinical teacher limited in time by a busy practise, follows the lines of least resistance, forgetful, though sometimes resentfully so, of the best needs of his class. Usually coexistent with a

pernicious lecture system is the habit of leaving those most favorable fields for proper education—the laboratory exercise and the ward or dispensary class—to assistants. No one has less desire to belittle the work of assistants or to lessen their independence than have I, but in the department in which the head lectures only the student naturally assumes that the work of subordinates—in laboratory or clinic—must be work of subordinate importance, and thereby he comes to have a wrong estimate of the live part of his education. The most ardent supporter of the lecture system can not say that he always holds the interest of his class. He may hold their attention and be flattered by copious note-taking, but this has for its object only one purpose—the final examination. The real education—the training which means power and which characterizes "the mind which is prepared"—can come only through independent but wisely directed observation, experiment and reasoning on the part of the student.

I have discussed elsewhere[12] how the latter system may be fostered, and am now glad to be able to reinforce my position by quoting from the recent very excellent address on this subject by Professor G. M. Jackson.[13] As to the share of the teacher Professor Jackson says:

> It is evident that each teacher must understand the curriculum as a whole. The laboratory man must be familiar with the clinical work. But this is not all. Since good teaching must take into account that which has gone before as well as that which is to follow, it is equally evident that the clinical man must be familiar with laboratory subjects and methods. We can not expect the best results in medical education until there is a better understanding and more cooperation between teachers of the various subjects all along the line. As medicine progresses, all phases appear more clearly as varied manifestations of the same underlying biological science, and only when this is realized will the clinical and laboratory work be more closely knitted together.

As for the student, it is suggested that he

> work out everything for himself by the method of discovery. This applies not only to the original observations, but also to the latter process of reasoning, whereby we proceed from particular data to general conclusions, and thence to rational action. The method of self-activity may therefore be expressed in a negative way by the following practical rules: Never tell a student anything he can observe for himself; never draw a conclusion or solve a problem which he can be led to reason out for himself; and never do anything for him that he can do for himself.

[12] "The Experimental Method: Its Influence on the Teaching of Medicine." Printed in this volume.

[13] Jackson, G. M., "On the Improvement of Medical Teaching," *Science*, XXXV., p. 566, 1912.

There are, of course, limitations to the application of this method, as lack of time, an overcrowded curriculum, inability on the part of the teacher to fully grasp the situation, and failure to always maintain sustained effort on the part of the student, but its value over the lecture system is so great that it should be followed in "so far as practicable" (Jackson) and should be supplemented by demonstrations and conferences or recitations rather than by lectures, if one truly seeks to prepare properly for the practise of medicine.

Influence of the Spirit of Investigation.—But aside from this training the university has another duty to the prospective practitioner of medicine. This is its duty in the encouragement of investigation, which is indeed a double duty, a duty to its students and a duty to the community it serves.

The question of allowing undergraduates to undertake independent original investigation is, I know, a debatable one. Certainly in most schools our overcrowded curriculum renders such work impossible unless a wise arrangement allows elective studies, as at Harvard in the fourth year, or as at Johns Hopkins in each year. My remarks on this subject are therefore based on the assumption that an elective system is possible in every school.

As every teacher knows, each class contains a considerable number of men who desire to pursue work, to a greater extent than the conventional course allows, on certain subjects or by special methods, or less frequently, perhaps, they desire, and are usually well qualified to undertake, minor investigative work. To the former, as well as to the latter, any effort spent in work beyond that given the entire class becomes, necessarily, for them, the acquirement of the methods of research and as this means a knowledge of the exact, painstaking methods by which the realms of the unknown are explored, it is an exercise which prepares the student for the daily routine research work of the physician who truly practises his profession. As a training for future work its value is definitely known, and the increased zest and enthusiasm exhibited toward their medical work by men who have had this opportunity are always evident. Pedagogically, therefore, it would seem advisable that every student should have the opportunity for minor investigative effort, in order that he may become acquainted at first hand with the careful methods of experimental medicine. The bearing of the tangible results of his work on the subject investigated is a matter

of little or no importance; the vital thing is the increased power which he himself acquires.

There is another way in which the encouragement of research aids the student, but which is possible only to those schools following the wise policy of appointing to professorial chairs teachers who are likewise investigators. The influence of such teachers in the development of independent and resourceful practitioners is the secret of the great success of our better schools. The correctness of this statement may be easily demonstrated.

If one examines courses in the same subject in a number of schools it is found that those which are best presented are under the control of men actively engaged in research work. Such men are alive to the advantages of new methods in their own subject and of new ways of applying old methods. Ever thinking and pondering about new methods of acquiring knowledge for themselves and their science, they appreciate better than does the non-investigator that which will aid the student to acquire knowledge, and in their teaching they bring to bear on the problems which the student has to face the same methods of attack which they use in their own researches. On the other hand, one finds the men who never or only occasionally contribute to the literature of their science are the men who confine their teaching to perfunctory routine courses, with a profusion of lectures, and who never bring the spirit or methods of the investigator into their teaching. So, likewise, it is with the student taught under these two conditions. The student who knows that he is working in a department actively emphasizing new methods and striving to develop new truths, knows that his instruction is presented in the spirit of the department, and thus receives that stimulus and inspiration which insures his approaching clinical medicine with a proper appreciation of the scientific method. The student under the method of the non-investigator, on the contrary, has no incentive other than that of acquiring a knowledge sufficient to allow him to pass an examination.

An allied argument lies in the fact that the medical school that fosters research attracts the best-trained men as students. We have, as is well known to many of you, a medical school in this country which has, for several years, arbitrarily selected from a larger number of prospective matriculants the certain definite number which it desires; the rest, sometimes nearly fifty per cent. of those accepted, go elsewhere.

Now this school has the highest requirements and perhaps the smallest alumni body of any prominent school in the country. It is not, therefore, a question of easy entrance or of the loyal influence of alumni, nor is it a question of better laboratory and hospital facilities, for other schools have equally good equipment in both respects. Likewise it is not a question of geographic location or center of population. The enviable position of this school is due solely to the policy of combining research with teaching and of appointing to its staff teachers who, with few exceptions, are also investigators.

As to the duty of the university to the community in the matter of research, there can be only one opinion. If the purpose of the machinery of medical education is to "bring healing to the nations," if the business of medicine is to "get people out of difficulties through the application of science and dexterity, manual and physical" (Cabot), then it is the duty of the university not only to teach known principles and methods, but to advance knowledge and methods by research.

It is futile to say that it is sufficient to teach and to utilize known methods of freeing people from difficulties, for the mere statement of such an attitude implies that an obligation exists to extend known methods, or to invent new ones, in the hope of overcoming difficulties acknowledged to be at present without remedy. The ethical force of this statement can not be denied. To teach a subject implies the attempt to diffuse the available knowledge of that particular subject-matter among a number of people for their good, as well as for the good of the community in which they live and work; equally true is it that such an attempt to teach available knowledge imposes upon the teacher the obligation to leave untried no means by which the knowledge of his subject may be increased. It is not the privilege of the teacher to leave this extension of knowledge to others. His profession of ability to teach a particular subject carries with it his obligation to the group or community he serves, of adding to his subject knowledge of which they may avail themselves. If this applies to the individual teacher, how much more forcibly does it apply to the university with its ever-widening community and ever-increasing interests?

On the other side of the question, the university should not forget that medical research tends to ameliorate social conditions by diminishing the causes of physical and mental ills. This ideal of medicine the university and its community should foster and develop, for it is

one of the greatest influences in our modern conception of social service; an influence, indeed, which was back of all Pasteur's work, and which he expressed in the statement of his desire to contribute "in some manner to the progress and welfare of humanity."

But aside from this altruistic ideal, I hold that research in the medical school offers important practical advantages to the university and that these advantages should not be forgotten by university authorities who pride themselves on applying business-like methods to the problems of education. A policy which attracts a better-trained class of students, which improves the character of the instruction, which stimulates the student to a better type of individual effort and which enhances the standing of the university in the community and the nation, is a policy which can not be ignored by university president, trustees or faculty.

The Relation of the Hospital to Medical Teaching and Research.—That the laboratories of our better medical schools are fully equipped for the kind of instruction which I have outlined, and that many are already fostering the "do it yourself" principle and the spirit of investigation, is well known. In the clinical years, on the other hand, the situation is not so satisfactory. Many a medical school while building and equipping modern laboratories has failed to care properly for its clinical teaching, and has continued to foster the amphitheater lecture. If the method of first-hand instruction, which I have outlined, is to be followed, then the hospital must become the laboratory of the clinical years and a school must own or absolutely control its hospital. This is necessary in order (1) that the heads of the clinical departments may have a continuous service under their immediate charge and to the conduct of which they may bring their own assistants; (2) that in connection with such service they may develop laboratories for teaching and research in addition to the usual clinical laboratory now used only for purposes of diagnosis; and (3) that resident physicians may be appointed for indefinite service in order that trained teachers and investigators in clinical medicine may be produced in the same way as trained teachers and investigators in the laboratory branches are now produced, and (4) that the head of the department may provide adequately for that intimate first-hand clinical instruction which can be secured only by placing the student in actual contact with the patient.

Some schools, as Michigan, Pennsylvania, Hopkins and Jefferson,

have already solved the problem by the establishment of their own hospitals. This is naturally the ideal course for all university schools and a future for which every school should plan. But in the absence of the possibility of immediate consummation of such an ideal, results almost as satisfactory may be obtained by the actual affiliation of municipal or independent hospitals with the stronger medical schools. A hospital has as much to gain by this arrangement as has the medical school, for while the chief duty of the hospital must always be the care of the sick and injured, this duty, as well as its other functions—the instruction of men who are to practise medicine and the advancement of medical knowledge by research—is best served by placing the conduct of the hospital in the hands of men highly trained in the methods of scientific medicine.[14] This would not only enable the hospitals

to fulfill a greater function in the development of thoroughly qualified physicians, but it would also be best for the patients, since they would have the benefit of the best methods of treatment under recognized experts. A campaign of education should be carried on to show our municipal authorities that the hospital will be the best conducted in the interests of its patients, and the community at large, if at the same time it is fulfilling its function as a great center of clinical teaching and research.[15]

Many examples may be presented of the ideal association of charity, teaching and research as the results of such affiliation; the most striking perhaps being the magnificent clinic of Müller in Munich and the clinics of the University of Leipzig. Here, as in many other continental cities and in England, the university authorities by agreement with the municipal authorities appoint the heads of the hospital clinics. The long continuance of this arrangement and the great fame of most of these clinics are sufficient proof that both municipal authorities and university authorities find it mutually advantageous.

We should bring about the same state of affairs in this country, and, in fact, a start has already been made. At Cincinnati the large municipal hospital has been placed in charge of the clinical teachers of the University of Cincinnati; in St. Louis, the Washington University has made a close affiliation with the new Barnes Hospital; in Boston, Harvard has made an affiliation with the Peter Brigham and several other special hospitals; in New York, Columbia University and the Presbyterian Hospital have established similar relations; in Cleveland,

[14] For a discussion of the advantages to be gained by the hospital, see Welch, W. H., "Advantages to a Charitable Hospital of Affiliation with a University Medical School," *The Survey*, XXVII., p. 1766, 1912.

[15] Bevan, A. D., "The Modern Medical School," *Jour. Am. Med. Assoc.*, LVIII., p. 652, 1912.

Western Reserve University has formed a combination with the Lakeside Hospital; in Chicago, Rush Medical College has had for a number of years the medical control of the Presbyterian Hospital, and recently has made similar contracts and arrangements with the Children's Memorial Hospital, the Home for Destitute Crippled Children and the Hospital for Infectious Diseases.[16]

How much better such an arrangement would be than that which now exists. At present in most schools the clinical teacher is a teacher mainly because he is fortunate enough to control a hospital service, and for this reason has been appointed on the university staff. In his appointment the school has no choice, for it must have for its students the advantages of the clinical material which he controls. Whether he be good, bad or indifferent, as physician, teacher or investigator, he must be retained as long as he holds his hospital position. He, on the other hand, is handicapped by the regulations and restrictions of a not always sympathetic lay board of hospital management and, more important still, by the absence of proper laboratory facilities and the aid of his own colleagues in the departments of bacteriology, immunology, pathology and pathological chemistry. These departments are coming more and more into active participation in hospital work, in diagnosis, prognosis and treatment, and should be as closely affiliated with the hospital as are the clinical chairs. Those of you who have read "The Corner of Harley Street,"[17] a most delightful series of letters by an English consultant, may remember the words quoted by the author from a lecture of a brother physician to postgraduates. Said the lecturer:

> Gentlemen, I should like the day to dawn when I could be met at the door of my hospital by a trained chemist, a trained bacteriologist, a trained pathologist, so that when I come to some complicated case I could say, "Chemist, a part of this problem is yours, take it and work it out. Bacteriologist, perform your share in elucidating this difficulty. Pathologist, advance, and do likewise."

These are not idle words. Since Ziemssen in the middle eighties established in Munich the principle of a clinical laboratory in the hospital, the idea has spread rapidly, until now every hospital worthy of the name has its clinical laboratory for the routine procedures of diagnosis. But this is not sufficient. The clinical chief must have the close cooperation of his colleagues in the departments of pathology, bacteriology, physiology and chemistry, and the student likewise must

[16] Bevan, *loc. cit.*

[17] "The Corner of Harley Street, being some Familiar Correspondence of Peter Harding, M.D.," Houghton Mifflin Co., 1911.

have the outfits of these departments at hand to aid him in his clinical studies. It is no longer enough to depend on the simpler procedures for the examination of urine, sputum, blood and other body secretions and fluids. The transportation across the city of tissues or fluids for examination in the laboratories of the school can no longer be countenanced. The progress of modern medicine, especially in pathological chemistry and immunology, demands for the benefit of the patient, as well as for the proper instruction of the student, detailed and oftentimes prolonged examinations under the hospital roof or at least within the boundaries of the hospital yard, and under the control not of assistants or internes, or dependent on occasional visits of a professor of pathology, bacteriology or chemistry, but under the constant supervision of such experts who do their teaching and research in the hospital and contribute their share to the diagnosis, care and treatment of the ills of the patients. This is the ideal of social service in medicine, the goal of all effort in medical education and research; and it is not Utopian. Already the University of Toronto has transferred its departments of pathology, bacteriology and pathological chemistry to the grounds of the hospital which furnishes its clinical instruction. Here not only the elementary instruction is given, largely aided by an abundance of fresh material from the hospital, but each advanced student serving as clinical clerk in the wards has always his desk, well-equipped locker and special outfit for the detailed investigation of his clinical material by laboratory methods, and, moreover, has always at hand his teachers in the laboratory branches to aid him in his clinical investigations. It was my good fortune recently to go over these departments with Professors Leathes and MacKenzie, who explained their workings to me. When I expressed my satisfaction at the ideal union of clinical and laboratory methods Professor Leathes said quietly, and as if there could be no other point of view, "Yes, we expect a student working in the wards to use in diagnosis the methods of pathological chemistry as he does his stethoscope." Do you know what this means? It means that the amphitheater clinic and the didactic lecture are to follow the two-year and three-year course and that the methods and instruction of the laboratory years are no longer to be divorced from the clinical teaching of the later years of the curriculum. It means that men are to be trained by the "do it yourself" method to become practitioners with power of accurate diagnosis and the "mind

which is prepared" to take advantage of every "chance" observation and opportunity. It means that the newer methods of biological, physical and chemical diagnosis, evolved through laboratory effort, are to work a transformation in medical teaching and medical practise analogous to that which came in the middle of the past century through the introduction of exact methods of physical examination. As physical diagnosis raised medicine above the plane of objective diagnosis and revealed the morphological changes in diseased organs of the interior of the body, so now the methods of physiological chemistry and immunology are destined to reveal the changes in the cells and fluids of the body which are dependent on intoxication, infection and altered metabolism and thus bring about an advance in methods of diagnosis, the fruits of which are almost beyond our powers of imagination.

Herein lies the most potent argument for close affiliation of school and hospital. The task, both from the teaching side and from the research side, demands united effort, common use of material and common financial responsibility. While any contract between university and hospital must leave the general support of the hospital in the hands of the hospital management, the school must be prepared to pay the salaries of attending staff, the cost of equipment and the expenses necessary for teaching and research and to assume the responsibility for the medical and surgical care of the patients and the general conduct of the scientific work. On the other hand, the hospital should leave the matter of appointments, subject to its nominal approval, entirely in the hands of the school, with the understanding that withdrawal or resignation from the school automatically would sever connection with the hospital, and *vice versa*. Such an arrangement settles most of the problems of medical education.

The Hospital Year.—So much for the preparation which the training, facilities and opportunities of the modern medical school should offer as leading to the degree of doctor of medicine. Should the state and the public demand more? Yes, the state, through its machinery for the protection of the individual, should demand a fifth year of hospital work, and this the public would force the state to demand if the easy-going public was thoroughly familiar with the insufficient requirements of many of our state licensing boards. Indeed, some states are already drafting laws to protect their citizens from the products of the poor medical schools of a neighboring state—

For example, the state of Minnesota has enacted a law enforcing an educational qualification as to the training of physicians who are allowed to practise in that state. The law was adopted in order to protect citizens of Minnesota against the graduate of commercial medical schools in neighboring states, and particularly of Chicago. In the present state of medical education such a measure is entirely justifiable.[18]

Such a law not only protects the community against the improperly prepared graduates of the poor school, but it encourages the good medical school to increased efforts.

The hospital year as a prerequisite to licensure is to-day a live topic of discussion; to-morrow it may be in this and in other states a requirement legally stated.[19] Indeed it is difficult to see how the progressive state of New York, the educational system of which is so wisely controlled by a special board of regents, can much longer delay in establishing such a requirement. But why wait for the regents to force this upon the schools? Already 80 to 90 per cent. of the men in the better schools secure hospital appointments. Why should not the schools compel the small minority of those who do not secure a hospital to take a fifth year in clinical instruction in the hospital which it controls and thus be prepared for the requirement which must inevitably come in this and other states. I realize fully that the deans of our various schools are divided on this question. Some take the position that although the hospital year is an excellent requirement, the burden of finding the hospital instruction for all its graduates should not be placed on the school; that the duty of the university is ended when it has given four years of instruction and that the fulfillment of the added requirement is an affair of the individual. What does this mean in the last analysis? Simply this, that a school holding this point of view is either lax in its entrance requirements or at fault in its methods of instruction; otherwise it would not fear the failure of its graduates to secure interneships. If this is true it has under the circumstances but one duty: as an educational institution, it must itself provide the

[18] Pritchett, H. S., "Education and the Nation," *The Atlantic Monthly*, April, 1912.

[19] There is only one school at present which requires the fifth hospital year, and that is the University of Minnesota. No state boards at present require the hospital interne year. Those which to a certain extent have initiated practical tests at their examinations are Massachusetts, Minnesota, Ohio and North Dakota, and to a lesser extent practical tests are being used in Colorado and Michigan. (Personal communication from N. P. Colwell, secretary, Council on Medical Education of the American Medical Association.)

fifth year of hospital work for its lame students. This is the point of view which is gradually forcing itself upon the school of the better grade, which, now that the pioneer stage of medical education is past, desires to itself complete the student's preparation, instead of turning him "over to others during this most valuable and important part of his preparatory work."[20] The proposition of Professor Peterson, of Michigan, that the council on medical education of the American Medical Association should conduct an inspection and classification of hospitals on the same basis as the inspection of medical schools is most timely. The data thus obtained would do much to clarify the situation, and, doubtless, mutual agreements between certain schools and certain hospitals of the same class could be reached as to the distribution of graduates for interne service. Such a systematization would allow school and hospital alike to see their defects and so rearrange their work as properly to care for the greatest number of properly prepared men. Only through the hospital year can we give the best type of practitioners to a most deserving but too confiding public; but to bring about the consummation of this ideal every university school and every community possessing a modern hospital must do its share.

These general remarks cover, in my opinion, the cardinal principles which should guide the modern medical school. They can not, perhaps, in every community, be enforced at once in their entirety, and doubtless now and then their adoption may be followed by backsliding, but no one who has given the subject serious thought can doubt that the future of medical education in this country depends on (1) the university school with a high entrance requirement, (2) instruction, in both laboratory and clinical branches, based on the method of observation and experiment, (3) clinical instruction in a hospital which the university owns or controls, (4) the principle of a fifth year of hospital instruction and (5) the fostering of the spirit of research.

And now finally let me congratulate Syracuse University on the high ideals it has set itself in the conduct of its medical school. Your course has been watched by all who are interested in medical education. Your responsibility is greater than perhaps you realize; there are those praying for you to continue your present progressive system, others hoping you may fail. Each group desires to point to you as an

[20] See Peterson, R., "The Relation of the Medical School to the Interne or Hospital Year," *Jour. Am. Med. Assoc.*, LVIII., p. 723, 1912.

object-lesson. I have full confidence, however, that the wise trustees of your university, supported and encouraged by your alumni and the physicians of Syracuse and its surrounding territory, will not only maintain the present high standards, but will inaugurate still greater advances and thus ensure for the practitioner of medicine in this community the "prepared mind" of Pasteur's adage.

THE INTERDEPENDENCE OF MEDICINE AND OTHER SCIENCES OF NATURE[1]

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Sixty years ago, when the American Association for the Advancement of Science was founded, all of the main divisions of the sciences of nature existed as they do to-day, but no greater change has come over the face of science during these years than the many subdivisions which have arisen. Then the naturalist or the natural philosopher—how unfamiliar even the names are beginning to sound!—or the chemist could follow with critical judgment at least the work of all who were cultivating his own broad field of science, and a single scientific association, such as ours, could unite all of the workers in the natural and physical sciences into a relatively homogeneous and compact group, supply their needs for intercourse with each other and furnish a comprehending audience for presentation of the results of scientific investigation. To-day no man of science can pretend to follow all of the work even in his own department, and the investigator more often than not must seek an audience capable of critical understanding and discussion of his studies in a society of biological chemists, or of experimental zoologists, or of plant pathologists, or of dairy bacteriologists, or whatever may be the body which represents his own particular corner of science.

We may regret the loss of many charming features which have been erased from the landscape of science by all of this minute specialization, of which no one can foresee the end, but such a sentiment is much the same and as unavailing as that for the return of the days of the stage-coach. The great instruments of progress in modern life—steam and electricity in the industries, subdivision of labor and increasing specialization in science—are not altogether lovely, but they are the conditions of advancement in material prosperity and natural knowledge.

A necessary expression of the changed conditions of modern science

[1] Address of the retiring president of the American Association for the Advancement of Science, delivered at the meeting in Chicago, December 30, 1907. Published in *Science*, January 10, 1908.

has been the rapid formation of more and more highly specialized societies, which, it must be admitted, meet the personal needs of many individual workers more fully than a general association, representative of all the natural sciences, can possibly do. But the horizon of a man of science must indeed be narrowly circumscribed, if he can not look beyond what he conceives to be his personal needs and the little plot of ground which he cultivates to those necessities of science as a whole which an organization such as ours is designed to serve. The common interests of science grow with its expansion, and the more minute and specialized its subdivision, the greater the need of an association representative of these common interests—a central, national organization which shall keep to the front the essential unity of all the sciences of nature and of man, and the vital importance to the welfare of the community of the extension and application of scientific knowledge in all directions.

In order to serve most efficiently these common interests of science the central organization requires from time to time readjustment in details of plan and working to changed conditions resulting from the development of science and national growth, but its underlying purpose remains always the same. This purpose is so fundamentally important that its attainment in the fullest measure possible by this association should secure the personal service, the active interest and the zealous loyalty of all scientific workers and lovers of science in this country. The association becomes a living organism through the devotion of its members to its interests and, when fired by this breath of life, the machinery of organization, otherwise inert, is made a powerful instrument for the advancement of science. Gratifying as has been the growth of the association in recent years in membership and usefulness, no one will claim that it has taken full possession of its rightful heritage. The membership of the association should be doubled, yes trebled, to secure needful additions to its resources and influence. The time is near, if it has not already arrived, when the association urgently needs a central office and the services of an executive officer and secretary sufficiently recompensed to enable him to devote his main time, thought and energies to the perfection of the organization, to the extension of membership, to the voluminous correspondence, to the arrangements for the meetings and to other manifold interests of the association. Familiarity with the benefits which such an arrangement has secured for the medical

profession through the remarkably effective reorganization within recent years of the American Medical Association leads me to place the first emphasis upon this direction of improvement for the organization of science.

In speaking, as I have done, of modern science as subdivided and specialized, in order to indicate some of the problems relating to the organization of this association, there is danger of giving a false impression to those not fully informed of the actual conditions of science. In truth, the boundaries between the divisions and subdivisions of the sciences are being rapidly effaced by a deeper insight into the nature and phenomena of the material universe. Natural science has been compared to a continent separated into kingdoms, but a more appropriate comparison, it seems to me, is to the spectrum composed of different rays which merge imperceptibly into each other and combine into one white light with radiant energy to be discovered beyond the limits of the visible.

Who will undertake in these days of physical chemistry to separate the domain of the physicist from that of the chemist? The problems of the geologist have long been recognized as essentially physical and chemical in their nature. An ever larger part of the biological sciences, including the medical, is opening to exploration and conquest by physical and chemical methods. To mathematics belongs the primacy, for the exactness of a science is in direct ratio to the degree with which its subject-matter can be investigated by measurement and calculation, that is by mathematical methods. The ideal thus implied has been fully attained only by celestial mechanics, but it is approached by some other departments of physics. It is in accord with this ideal that Priestley admirably said that the object of science is "to comprehend things clearly and to comprise as much knowledge as possible in the smallest compass." The ultimate problems of reality and of knowledge belong to metaphysics which we may, following Descartes, bury deep in the soil as the root of the tree of science.

While this mutual dependence of all the sciences of nature, so significant of the operation everywhere of common principles and forms of energy and of an underlying uniformity in the order of nature, both animate and inanimate, is closest between the physical sciences in the restricted sense, it is strikingly illustrated in the history of the biological sciences, and it has seemed to me that the consideration of certain

aspects of the interdependence of that department of biological science with which I am most familiar and the other sciences of nature would be an appropriate theme for an address by a representative of the science of medicine upon this occasion. It is to be understood that under the sciences of nature I include those of inanimate nature, the physical sciences, as well as those of organized beings, and indeed I shall dwell more particularly upon relationships between the medical sciences and physics and chemistry, for the points of contact between the various branches of biological science and medicine are self-evident and more familiar.

It need hardly be said that any systematic and full consideration of this broad theme far transcends the limits of an address and that in selecting particular aspects of the subject and certain illustrations I am quite aware that other points of view and other examples will come to the minds of my hearers as equally, if not more, worthy of presentation. Medicine has derived such inestimable benefits from the physical and natural sciences that I desire to lay some emphasis upon the services which it has rendered to them. For my present purpose it is not necessary to assign any limits to the operation of physical and chemical laws in living beings, for the most extreme vitalist must leave so large a part of the phenomena of living beings under the subjection of these laws that their application in medical and biological studies must always be of the highest importance.

An historical sketch, necessarily brief and inadequate, of some of the principal phases in the reciprocal relations between medicine and the physical sciences, up to the time when the latter became fully independent at the close of the seventeenth century, will show with what propriety medicine has been called the "mother of the sciences."

Physical science has derived from the Greeks no such extensive records of sound observation and experience as those which medicine has inherited from the writings of Hippocrates and his followers. Physical theories embodied in the speculations of the nature-philosophers concerning the constitution and properties of matter furnished the starting point for the Hippocratic doctrine of the four humors and other generalizations, but these theories sat so lightly upon Hippocrates that his name is attached to that method of medical study which rejects dogma, authority and speculation and confines itself to the observation and record of clinical facts. As Gomperz in his admirable work on the

"Greek Thinkers" has clearly pointed out, the age of enlightenment in scientific thought was inaugurated by Hippocrates and his medical contemporaries.

The influence of physical theories upon medical thought in antiquity can be traced not only in the humoral doctrines of Hippocrates and of Galen, but also in rival schools, and especially in the so-called methodic school founded upon the atomistic philosophy of Democritus, which is so interesting in the history of scientific theories. As this school produced such admirable physicians as Asclepiades, Soranus and Aretæus it is to be regretted that their solidistic pathology was so completely displaced by the authority of Galen.

The large body of medical knowledge and doctrine which had grown up during the six centuries since Hippocrates was further developed and fixed by Galen at the end of the second century after Christ into a system not less complete in its field, nor less satisfying to the minds of men for nearly fifteen centuries, nor scarcely less remarkable as a product of the human mind than the physical and philosophical systems of Aristotle. Within their respective spheres the system of doctrine of each of these great men has exerted a similar dominating influence upon human thought and has met a similar fate through influences almost identical.

Although the contributions of the Greeks to mathematics were of the highest order, and the names of Aristarchus, Eratosthenes, Hipparchus and Ptolemy attest the great debt of astronomy to the school of Alexandria, and Archimedes had founded one branch of mechanics, and the works of Aristotle on "the history" and on "the parts of animals" entitle him to be called the "father of zoological science," I think that it is safe to say that the largest body of ordered natural knowledge in any single domain bequeathed by the ancients to posterity was represented by medicine. The botanists trace the beginnings of their science to the physicians, Theophrastus and Dioscorides, but botany was then, as it long remained, an integral part of pharmacy.

As medicine, practically in the shape in which it left the hands of Galen, continued for many centuries to be the shelter for most of the natural sciences, it is worth considering how worthy a home it furnished. For this purpose it is not necessary to enter into details of doctrine or even the state of existing knowledge. A few words concerning the general scope and spirit of medicine, as conceived and transmitted by the Greek physicians, must suffice.

Gomperz formulates the ideal of these physicians as regards their conception of the relation of medicine to the philosophy of nature in these words:

> The human being is a part of the whole of nature, and can not be understood without it. What is wanted is a satisfactory general view of the process of the universe. Possessing this, we shall find the key in our hand which will open the most secret recesses of the art of medicine.

Certainly such an enlightened conception of the relations of medicine, however unattainable it may be, is broad enough to provide welcome lodging under the roof of the healing art to any additions to the knowledge of nature. Although priestly and magic medicine and charlatanry existed then by the side of rational medicine, as they have always done, the Galenic system, which was a development of the Hippocratic, was in essence observational and inductive, mainly physical, as distinguished from vitalistic, and nearly devoid of superstition and the supernatural. Galen conceived medicine as a science and constituted anatomy and physiology its basis. He himself made valuable use in his physiological studies of the method of experiment, the singular and almost unaccountable lack of which is largely responsible for the fantastic, though often singularly prophetic, ideas and the sterility of the Greek natural philosophers as contributors to natural knowledge. Although later cultivators of the domain of medicine followed far behind these ideals of Greek medicine, there survived enough of their spirit to enable us to understand why the sciences of nature were for so long a time fostered within this domain, which furnished them a fitting and no unworthy abode until they were strong enough to build their own homes.

Although the Byzantine, Arabic and medieval periods afford a number of interesting illustrations of my theme, I shall not take time to consider them, for these periods were relatively unproductive for most of the sciences as well as for medicine. It may be noted, however, that the majority of the names which appear in the histories of the various natural sciences for these times figure also in the history of medicine.

The great awakening of western Europe, marked by the revival of learning and the reformation, stirred the long dormant spirit of inquiry and led to revolt against authority, a fresh outlook upon a wider world, the study of original sources, the questioning of nature at first hand and the search for new knowledge in all her kingdoms. The seat of learning was transplanted from the cloisters to the universities, which multi-

plied and flourished in the sixteenth and seventeenth centuries as never before.

For medicine and the sciences of nature the fire was kindled and for two centuries burnt brightest in the universities of northern Italy. Here the science of human anatomy was reformed and marvelously developed by Vesalius and an illustrious line of successors in the sixteenth century, and from this period onward anatomy never ceased to be taught by practical dissection, that is to say, by the method of the laboratory. It deserves to be emphasized that for over two hundred and fifty years human anatomy was the only subject taught in the universities by the laboratory method and that it thereby acquired a commanding position in the study of medicine. Bearing in mind the exceptional educational value thus imparted to the study of anatomy and that for a long time medicine was the only technical subject taught in the universities, we can not doubt that under conditions existing previous to the nineteenth century the study of medicine furnished the best available training for the pursuit of any branch of natural science. From his practical anatomical work the student could acquire the habit of close observation, manual dexterity and the sense for form in nature, and learn that real knowledge comes only from personal contact with the object of study. The term "comparative anatomy," even if it serves no other useful purpose, at least points to the historical fact that human anatomy was the starting point and basis of comparison for the morphological study of the lower animals.

In the sixteenth century practically all of the valuable contributions to botany and to zoology were made by physicians, so that natural history scarcely existed apart from medicine. Of the medical contributors to botany it must suffice to mention the names of Brunfels, Fuchs, Dodoens, Gesner and above all Cesalpinus, who has been called "the founder of modern scientific botany," the most important name before John Ray in the history of systematic botany, and a distinguished figure likewise in medical history. Of names associated with the history of zoology in this century the most important are those of the physicians, Conrad Gesner, a marvel of encyclopædic learning, and Aldrovandi, who ranks with the founders of modern zoology and comparative anatomy; of lesser lights Edward Wotton may be singled out for mention as the pioneer English zoologist. He was doctor of medicine of Padua and of Oxford, president of the Royal College of Physicians, and physician to Henry VIII.

A name of the first rank in the history of science is that of the physician, Georg Agricola, who founded before the middle of the sixteenth century the science of mineralogy and developed it to a state where it remained for nearly two hundred years without important additions. I may here remark in passing that the first American chair of mineralogy was established in 1807 in the College of Physicians and Surgeons of New York and was occupied by Dr. Archibald Bruce, a name familiar to mineralogists, the founder of the first purely scientific journal in this country, the *American Journal of Mineralogy,* which was the immediate predecessor of Silliman's *American Journal of Science.*

The difficult step from Hippocrates and Galen to Euclid and Archimedes was surmounted by several physicians of the sixteenth century, as it has also been repeatedly in later times. The reader of Don Quixote will recall that as late as the seventeenth century the physician was also called "*algebrista*" in Spain, a survival of a Moorish designation—and the sixteenth-century physicians Geronimo Cardano, as extraordinary a figure in the history of medicine as in that of mathematics, and Robert Recorde, the author of the first treatise on algebra in the English language, exemplified the union of the healing art with the pursuit of mathematics as strikingly as did the Sedbergh surgeon, John Dawson, in the latter part of the eighteenth century, who had eight senior wranglers among his pupils and was one of the few British analysts of the period who could follow the work of the great contemporary, continental mathematicians. It may here be mentioned that of the celebrated Bernoulli family of mathematicians, two of the most distinguished, John and Daniel, were doctors of medicine, the latter being for a time professor of anatomy and botany at Basel.

The student of medical history, who takes up a history of physics, such as that of Rosenberger, will probably be surprised to find how many of the contributors to the latter subject in the sixteenth century were physicians and that among these are such old friends as Fernel and Fracastorius, whom he has identified so intimately with the annals of his profession. It is to be presumed that he already knew that the most famous of all, Copernicus, was a doctor of medicine of Padua and practised the medical art gratuitously among the poor in Frauenburg.

Far more important for the subsequent history of science than any relations between medicine and physics at this period was the union between medicine and chemistry effected by Paracelsus and strengthened

by van Helmont and Sylvius in the following century, a union so intimate that for nearly a century and a quarter chemistry existed only as a part of medicine until freed by Robert Boyle from bonds which had become galling to both partners. The story of this iatro-chemical period, as it is called, has been told by Ernst von Meyer in his fascinating "History of Chemistry" in a way not less interesting to the student of medicine than to that of chemistry, and should be there read by both.

In reply to the question what benefit accrued to both medicine and chemistry from their mutual interaction during this period von Meyer says:

> **The answer is, a mutual enrichment, which did almost more for chemistry than for medicine; for the former was raised to a higher level through being transferred from the hands of laboratory workers, who were mostly uneducated, to those of men belonging to a learned profession and possessing a high degree of scientific culture. The iatrochemical age thus formed an important period of preparation for chemistry, a period during which the latter so extended her province that she was enabled in the middle of the seventeenth century to stand forth as a young science by the side of her elder sister, physics.**

Paracelsus in carrying out his program that "the object of chemistry is not to make gold but to prepare medicines" made the pharmacist's shop a chemical laboratory and until the establishment of laboratories by Thomas Thomson and by Liebig in the first quarter of the nineteenth century this continued to be the only kind of laboratory available for practical training in chemistry. Through this portal entered into the domain of chemistry Lemery, Kunkel, Marggraf, Klaproth, Scheele, Proust, Henry, Dumas and many others. Liebig, who also began as an apothecary's pupil, has graphically described these conditions.

That strange, iconoclastic genius, Paracelsus, typifies, as no other name in science, the storm and stress, the strife, the intellectual restlessness and recklessness of the sixteenth century which prepared the way for the glorious light of science which illuminated the following century. With boundless enthusiasm minds, now fully liberated from the bondage of authority, entered upon new paths of philosophical thought and scientific discovery and achieved triumphs unequaled even in the nineteenth century. The great achievement was the full recognition and the fruitful application of the true method of science in all its completeness.

Although isolated and limited use had been made of the method of

experiment in former times—I have already cited Galen and I might have added physicians of the Alexandrine school—the real birth of experimental science was toward the end of the sixteenth and the beginning of the seventeenth centuries. Medicine can hardly be said to have presided at this birth, but its influence was not absent. Galileo was a student of medicine, one of his teachers being the celebrated physician and botanist, Cesalpinus, when in 1583 he watched the great bronze lamp swinging before the high altar of the Cathedral of Pisa, and I question whether it would have occurred to any one without some interest in medicine to determine the isochronism of the pendulum by counting the beats of the pulse. It seems improbable that without his medical training Galileo would have made the measurement of the pulse the first application of the new principle and have called the instrument the pulsilogon. Nevertheless we must bear in mind that natural philosophers of this period and throughout the seventeenth century were greatly interested in anatomy and physiology. Dr. Weir Mitchell in an address, as charming as it is erudite, has called attention to interesting observations of Kepler on the pulse, which the great astronomer believed to have some relation to the heavenly motions, in this and certain other views exemplifying, as some modern physicists have done, the compatibility of a firm hold of positive scientific truth with an irresistible tendency to mysticism and occult science. Kepler was not, as has been stated, the first actually to count the pulse, for we read that as long ago as the Alexandrine period Herophilus timed the pulse with a water-clock.

But if Galileo was only half a doctor of physic, as Dr. Mitchell calls him, his elder contemporary, William Gilbert, second in importance only to Galileo among the creators of experimental science, the founder of the science of magnetism and a significant name in the history of electricity, was fully identified with the profession, being the most distinguished English physician as well as man of science of his day, physician to both Queen Elizabeth and James I., and president of the Royal College of Physicians.

Galileo's younger contemporary, William Harvey, the discoverer of the circulation of the blood, occupies in the history of experimental science an independent position, quite unlike that of the other experimental physiologists of the century. These other physicians, as Sanctorius, Borelli, Lower, Mayow, consciously took possession of the

method of experiment as a powerful and newly discovered instrument of research and were swayed in all their physiological work by the discoveries of the physicists. Not so Harvey, who was influenced but little by contemporary physical science and is linked on, not to Galileo or to Gilbert, as exemplars of experimentation, but in a very direct way to the experimental physiologist, Galen, and to Aristotle, as well as to the Italian anatomists of the preceding century. Harvey's genuinely scientific mind was in greater sympathy with Aristotle than with the essentially unscientific Lord Bacon, who was his patient and of whom he said, "He writes philosophy like a Lord Chancellor."

There is no more striking characteristic of seventeenth-century science than the wide range of inquiry covered by individual investigators. The natural sciences were no longer apprenticed to medicine, after Boyle had liberated chemistry, but the problems of anatomy, of physiology and even of practical medicine were not separated from those of the natural philosopher and of the naturalist. With unparalleled versatility every one seemed to roam at will over the whole domain of knowledge and thought. How they leaped and tumbled in the virgin fields and hied "to-morrow to fresh woods and pastures new"!

Descartes was an anatomist and physiologist as well as philosopher, mathematician and physicist, and John Locke, the other great liberator of thought in this century, was educated in medicine, practised it and, like Boyle, accompanied Sydenham on his rounds. Kepler studied the pulse, contributed to physiological optics and calculated the orbits of the planets. Borelli was an important mathematician, physicist and astronomer, as well as one of the greatest physiologists and physicians of the century. Bartholinus was also professor of mathematics as well as of medicine, and discovered the double refraction of Iceland spar. His even more remarkable pupil, Steno, left a name memorable in geology and paleontology as well as in anatomy and physiology, and died a bishop of the Roman Catholic Church. Mariotte, a pure physicist, discovered the blind spot in the retina. Boyle anatomized, experimented on the circulation and respiration, started chemistry on new paths and perpetuated his name in attachment to an important physical law. Hooke, most versatile of all, claimed priority for a host of discoveries, and did in fact explore nearly every branch of science with brilliant, though often inconclusive, results. Malpighi was an investigator equally great in vegetable and in animal anatomy and physiology, and

what a glorious time it was for the microscopists, like Malpighi, Leeuwenhoek, Swammerdam and others, who could immortalize their names by turning the new instrument on a drop of muddy water, or blood, or other fluid, or a bit of animal and vegetable tissue! From the funeral sermon upon Nehemiah Grew, practitioner of physic and one of the founders of vegetable anatomy and physiology, we are assured that he was "acquainted with the theories of the heavenly bodies, skilled in mechanicks and mathematicks, the proportions of lines and numbers, and the composition and mixture of bodies, particularly of the human body" and also "well acquainted with the whole body of Divinity and had studied Hebrew to more proficiency than most divines."

The early proceedings of the various scientific societies and academies, started in this century and destined to become powerful promoters of science, afford excellent illustrations of the wide scope of scientific inquiry. A quotation from the narrative of the famous mathematician, Dr. Wallis, gives further evidence of the position of the medical and other sciences in the aims and work of the little band of thoughtful students of nature who assembled in Oxford in 1645 and later in London, constituting the so-called invisible college, which grew into the Royal Society. He says:

> Our business was (precluding matters of theology and state affairs) to discourse and consider of philosophical enquiries and such as related thereto:—as Physick, Anatomy, Geometry, Astronomy, Navigation, Staticks, Magneticks, Chymicks, Mechanicks and Natural Experiments; with the state of these studies and their cultivation at home and abroad. We then discoursed of the circulation of the blood, the valves in the veins, the venæ lacteæ, the lymphatic vessels, the Copernican hypothesis, the satellites of Jupiter, the oval shape (as it then appeared) of Saturn, the spots on the sun and its turning on its own axis, the inequalities and selenography of the moon, the several phases of Venus and Mercury, the improvement of telescopes and grinding of lenses for that purpose, the weight of air, the possibility or impossibility of vacuities and nature's abhorrence thereof, the Torricellian experiment in quicksilver, the descent of heavy bodies and the degree of acceleration therein, with divers other things of like nature.

The work and publications of the small group of physicians and men of science composing the Accademia del Cimento, which was established in Florence in 1657 and flourished unfortunately for only ten years, exemplify in an equally striking manner the combination of medical with other scientific pursuits and the wide range of study.

Borelli, the most important member of this academy, founded the so-called iatro-physical school of medicine, which contested the field

for supremacy with the iatro-chemical, to which I have already referred, during the greater part of the seventeenth century. The story of these two schools is epochal and occupies the larger part of the history of physic during this century. Medicine owes to adherents of each school a large debt for important contributions to knowledge and fresh directions of thought. Where physical methods and knowledge, as they then existed, were applicable, as in investigation of the circulation and of the action of muscles, the iatro-physicists carried off the palm, Borelli's "De motu animalium" being one of the medical classics. But notwithstanding the great inferiority of chemistry to physics at this time the paths of discovery opened, although not traveled far, by the iatro-chemists have led to more important results. The beginnings of our knowledge of digestion and of secretion and even of the chemistry of the blood and other fluids are to be traced in the main to the iatro-chemical school, and the study of fermentation, although this was not conceived in the same sense as to-day, of gases, salts, acids and alkalis was of importance to medicine as well as to chemistry.

There never has been a period in medical history, not even in recent years, when so determined an effort was made to convert medicine into applied physics and chemistry as that in the seventeenth century. Descartes's dualistic philosophy, which left no more room for the intervention of other than mechanical forces in the organized world than in the inorganic, had great influence upon the minds of physicians as well as of physicists. Galileo had founded, and a line of great experimental philosophers from him to Newton had vastly extended, the science of dynamics, which then seemed to many, as in potentiality it may be, as applicable to all the activities of living beings as to the inanimate universe. There came in the first quarter of the century the greatest physical discovery in the history of physiology, that of the circulation of the blood, which opened the large biological tract of hæmodynamics to rewarding study by the new physical methods. The balance, the pendulum-chronometer, the thermometer and other newly invented instruments of precision were turned to good account in anatomical, physiological and pathological investigations, and physicians began to count, to weigh, to measure, to calculate and to discover a world of form and structure hidden from their unaided vision. Such chemistry as existed was pursued almost exclusively by physicians and primarily in the interest of medicine.

What wonder, then, that physicians who came under the influences of this great awakening in physical science and took no small part in its advent and promotion, should have entertained hopes, soon doomed to disappointment, of the benefits to medicine from application of the new knowledge and have promulgated hypotheses and systems of doctrine which seem to us so false and extravagant! Great as was the advance in physical knowledge, it was utterly inadequate for many of the purposes to which the iatro-physicists and iatro-chemists applied it, and to this day many of their problems remain unsolved.

Grateful we should be for valuable discoveries and new points of view which medicine owes to these men, often so unjustly criticized, but the time had come for men of our profession to resume the Hippocratic method of collecting facts of observation within their own clinical field, and Sydenham, of all the physicians of his century the name, next to Harvey's, most honored by medical posterity, in calling out, "back to Hippocrates!" turned the face of medicine again toward nature.

There are interesting points of comparison between Sydenham's position in the history of medicine, and that of his fellow-countryman and contemporary, John Ray, in natural history. I am sorry that my profession, which has fostered so many ardent students of nature, including Linnæus and Agassiz, the respective bi-centenary and centenary anniversaries of whose birth have been celebrated with such enthusiasm in the year now closing, can not claim this greatest naturalist of his century. Both Sydenham and Ray stood apart from the great scientific movement of their day; both, little influenced by theory or tradition, concentrated their efforts strictly within their respective fields of observation, and both introduced new methods of studying their subjects. As Ray, the plants and animals, so Sydenham described diseases as objects of nature, his discriminations and descriptions being in several instances the first, and to this day in some cases unsurpassed and unimpaired by new knowledge. Like Ray, he was not a mere species-monger, but he had the synthetic power to assign the proper place to single observations and to combine them into well-ordered groups. By way of contrast, the attempt of Linnæus to classify diseases into species and genera, although of some historical interest, was utterly barren, the subject-matter permitting no such method of approach as that which enabled this great systematist to start a new epoch in botany and zoology.

With the close of the seventeenth century we reach a dividing line, which limitations of time compel me to make on this occasion a terminal one, in the historical survey of the interrelations of medicine and the natural sciences. I can not, however, refrain from at least the bare mention of the influence of physicians on the development of science in America—a theme which I hope on some other occasion to take up more fully. Leonard Hoar, doctor of medicine of Cambridge, England, brought something of the new experimental philosophy to America, and during his short incumbency of the presidency of Harvard College (1672–1674) planted the first seeds of technical training on American soil, but too early for them to germinate. Of much greater importance was Cadwallader Colden, an Edinburgh doctor, acquainted with the Newtonian mathematics and physics, and a botanist of note in his day, who did much to instil an interest in physical and natural science among physicians and others in Philadelphia and New York in the first half of the eighteenth century. Besides John Bartram, who studied and to some extent practised physic, the founder on the banks of the Schuylkill of the first botanical garden in this country, there is a long line of American medical botanists, as Clayton, Colden, Mitchell, Garden, Kuhn, Wistar, Hosack, Barton, Baldwin, Bigelow, Torrey, the teacher and collaborator of Asa Gray, himself a graduate in medicine, Engelmann, whose names are perpetuated in genera of plants, and many others up to this day. Until the coming of Agassiz, who trained many who did not enter medicine (although among his pupils were also not a few medical men, including the Le Contes and A. S. Packard), most of the zoologists were also physicians, and Agassiz found already at work in his field in Boston the physicians, Gould, Storer, Harris, and one worthy of a place by his side, Jeffries Wyman. Of the delightful naturalist type of physician there have been many, such as Samuel Latham Mitchell, John D. Godman, Jared Kirtland, and above all a man who belongs to the world's history of biological and paleontological science, Joseph Leidy, whose monument was recently dedicated in Philadelphia. Geologists will call to mind such names as Gibbs, Newberry, John Lawrence Smith, also a chemist and mineralogist, and the Le Contes; and ethnologists the names of Samuel G. Morton, Daniel G. Brinton and Edward H. Davis. How many of the Arctic explorers from this country, as Kane, Parry, Hayes, Schwatka, as well as from England, have been physicians! There have been many whose interest

in science was first awakened by the study of medicine, but who were not graduated as doctors, as Joseph Henry, Sears Cook Walker, Thomas Sterry Hunt and Spencer F. Baird. Particularly interesting as investigators in physical science were members of the medical families of the Drapers, the Le Contes and the Rogers. This bare mention of a few of the American medical contributors to science, mostly of an earlier period, will perhaps afford some indication of the services of medicine to scientific development in this country.

After the seventeenth century in Europe the natural sciences, though often cultivated by those educated in medicine and practising it, were independent and followed their own paths, which, however, communicated by many by-ways with the road of medicine and with each other.

Botany and zoology acquired their independent position probably more through the work of Ray and Willughby than by that of any other naturalist. Botany, however, remained for over a century still mainly in the hands of physicians. An interesting chapter in its history is the story of the various apothecaries' and other botanical gardens established through the efforts of physicians and conducted by them primarily for the study of the vegetable materia medica. From such beginnings has grown the Jardin des Plantes in Paris, started by two physicians, Herouard and la Brosse, in 1633, into the great museum of natural history made by Buffon, Cuvier and others as famous for the study of zoology as by Brongiart and his successors for botany. Less humble was the foundation of the British Museum and its appanage, the great Museum of Natural History in South Kensington, the gift to the nation of his valuable collections in natural history and other departments by Sir Hans Sloane, a leading London physician in the first half of the eighteenth century.

Boyle's name is associated especially with the foundation of chemistry as a separate science. William Cullen deserves to be remembered in the history of this science, who, although not an important contributor to chemistry as he was to medicine, was in the second half of the eighteenth century the first to raise the teaching and study of chemistry to their true dignity in the universities of Great Britain, and imparted the first stimulus to his pupil and successor in the Edinburgh chair of chemistry, William Black.

Mechanics, never really dependent upon medicine, was lifted by Newton to analytical heights, rarely scaled by disciples of Æsculapius,

although, as Thomas Young and Helmholtz have exemplified, not wholly beyond their reach. But not all of physics stands on the lofty plane of abstract dynamics constructed by Newton, Lagrange, Laplace and Gauss, the highest probably hitherto attained by the human intellect. There have been many educated in medicine who have made notable contributions to the physics of sound, heat, light, magnetism, electricity and the general properties of matter and energy. I have collected, without any pretence to exhaustiveness, the names of over a hundred physicians or men trained for the practise of medicine or pharmacy who have made contributions to physics sufficiently notable to secure them a place in the history and records of this science. A few of the more important are Gilbert, van Musschenbroek, Sir William Watson, Black, Galvani, Berthollet, J. W. Ritter, Olbers, Wollaston, Thomas Young, Oersted, Dulong, Mayer, Thomas Andrews, Sainte-Clair Deville, the Drapers, Foucault, Helmholtz. Sir Humphry Davy literally sprang out of the lap of medicine into the Royal Institution, just founded by Count Rumford, who himself had begun the study of medicine before he left his native country. If the surgeons of England at that time had only heeded what Davy told them concerning the anesthetic properties of nitrous oxide gas, America would have been deprived of the greatest service which she has rendered to medicine.

In the long line of important physiologists of the past century who represent especially the physical direction of investigation in their important branch of medicine and biology, there are not a few whose names find a place in the histories of modern physics, as E. H. Weber, Du Bois Reymond, von Brücke, Ludwig, Fick, Vierordt, Poiseuille and others, and the studies of the botanists, Pfeffer and de Vries, on the turgor of vegetable cells opened an important field of physical chemistry.

Aspects of my subject, full of interest, which I can now barely touch upon, are the influence of previous medical or biological training upon the work of a physicist or chemist, and closely connected with this the extent to which purely physical problems have been approached from the biological side. Call to mind how the central physical and chemical problem of the eighteenth century, the nature of combustion, was throughout this period intimately associated with the kindred physiological problem of respiration, and how John Mayow in the seventeenth century, approaching the subject from the biological side, reached a conclusion in accord with that fully demonstrated a century later by

Lavoisier, who thereby opened a new era for physiology as well as for chemistry. For the first time clear light was shed upon the function of respiration, the nature of metabolism and the sources of animal heat, and such physical interest was attached to the study of these physiological phenomena that physicists of the rank of Laplace, in association with Lavoisier, Dulong, W. E. Weber, Magnus, A. C. Becquerel, Hirn, Regnault, and of course Helmholtz, have all made valuable contributions to the elucidation of these subjects.

The study of electricity, especially after the physiologist, Galvani's epochal discovery, more correctly interpreted by Volta, engaged the attention of physicians and physiologists scarcely less than that of physicists. The latter became greatly interested in animal electricity, a subject partly cleared up by the physicists, Ritter and Nobili, but mainly by the physiologist, Du Bois Reymond. Ostwald points out, as a matter of interest in the history of the human mind, that the physician Soemmering was led to conceive of the transmission of intelligence by electricity from analogy with the conveyance of impulses by the nerves, and thus to invent his practically useless form of the electric telegraph. However fanciful such a relationship may be, it is interesting, as Sir David Brewster discovered, that the first proposal for an electric telegraph worked by statical electricity was made and actually carried into effect as early as 1753 by the Greenock surgeon, Charles Morrison. It is now well understood that no one has the sole credit of inventing the electric telegraph, the idea of which was implicit in Stephen Gray's observation in 1727 of the transmission of electricity by a wire.

Of curious interest is the introduction of electricity for the treatment of disease by the physicists, Kratzenstein, Nollet and Jallabert, shortly before the middle of the eighteenth century, who reported cures by its use.

There is no more striking illustration of the correlation of two apparently distinct lines of approach to the same problem than the attack from the biological and from the purely physical sides upon the thermodynamic problem, which is as fundamental for biology as for physics. The conception of the principle of conservation of energy was supplied independently and almost simultaneously on the one hand by students of the conditions of mechanical work done by the animal machine and on the other hand by investigators of technical machines. Much of the essential preliminary study was on the biological side by

Boyle, Mayow, Black and Lavoisier. Mainly from the same side the physician and physicist, Thomas Young, first formulated the modern scientific conception of energy as the power of a material system to do work. Davy and Rumford contributed, and from the physiological side Mohr, Mayer and Helmholtz, and from the purely physical side, after preliminary work by Poncelet and Sadi-Carnot, Joule, Thomson and Clausius reached the same grand conception. The first to enunciate clearly and fully the doctrine of the conservation of energy and to measure the unit of mechanical work derived from heat was the physician, J. R. Mayer. Joule's work completed the demonstration, but Mayer's name is deservedly attached to this principle by Poincaré and others, as Lavoisier's is to that of the conservation of mass, and Sadi-Carnot's to the principle of degradation of energy. As regards this last principle it is almost as interesting to biologists as to physicists that in the so-called Brunonian movement, discovered by the physician and more eminent botanist, Robert Brown, and the subject of interesting physical investigations in recent years, we behold an apparent exception to the principle of degradation of energy, such as Clerk Maxwell pictured as possible to the operations of his sorting demon.

I must forego further citation of examples of this kind of correlation between the work of physicists and of physiologists, and leave untouched the chemical side, which is much richer in similar illustrations. The significance to organic chemistry of the synthesis of urea by Wöhler, and to agricultural chemistry of the bacteriological studies of nitrification in the soil and fixation of nitrogen in plants, will perhaps indicate how large and fascinating a field I must pass by.

The great advances in physics and chemistry initiated in France toward the end of the eighteenth and beginning of the nineteenth century were quickly reflected upon the medical and biological sciences through influences which in large part are attributable to this new movement in physical science. New methods of physical examination of the patient were introduced, and pathology and experimental and chemical physiology were developed as biological sciences of the first rank. This reformation of the medical sciences in the first third of the nineteenth century was mainly the work of Frenchmen, the great names in this development being those of Lavoisier, Bichat, Laennec and Magendie, the last a friend and physician of Laplace, and contemporary of Cuvier, who represented a like movement in zoology.

Liebig, the pupil of Gay-Lussac and founder of biological chemistry as a distinct science, carried in the third decade of the century the new spirit to Germany, where Johannes Müller and his pupils became the center of a movement which rescued medicine and biology from the shackles of the philosophy of nature and has given Germany the supremacy in these fields of science. The experimental physiological work of the brothers Weber, two being physicians and the third the great physicist who was so intimately associated with Gauss in Göttingen, was of great influence in introducing the physical direction of physiological research, but Magendie stands first in making the experimental method the corner-stone of normal and pathological physiology and pharmacology.

Most pertinent to my theme is it to note that the light which has transformed the face of modern practical medicine came in the first instance not from a physician, but from a physicist and chemist, Pasteur. The field of bacteriological study was placed on a firm foundation and thrown open to ready exploration by Robert Koch, and thereby that class of diseases most important to the human race, the infectious, became subject in ever-increasing measure to control by man. Thus hygiene and preventive medicine, through their power to check the incalculable waste of human life and health and activities, have come into relations, which have only begun to be appreciated, with educational, political, economic and other social sciences and conditions, and with the administration of national, state and municipal governments. It is an especial gratification to record the stimulating recognition of these relationships by the social and economic section of this association in which was started a year and a half ago a movement for public health, particularly as related to the federal government, which has already assumed national significance.

To the marvelous growth of the medical and other sciences of living beings during the past century, and especially in the last fifty years, physics and chemistry and the application of physical and chemical methods of study have contributed directly and indirectly a very large and ever-increasing share. In many instances there is no telling when or where or how some discovery or new invention may prove applicable to medical science or art. Who could have dreamed in 1856 that Sir William Perkin's production of the first aniline dye should be an essential link in the development of modern bacteriology and therefore

in the crusade against tuberculosis and other infectious diseases? As Robert Koch has said, it would have been quite impossible for him to have developed his methods and made his discoveries without the possession of elective dyes for staining bacteria, and no other class of coloring agents has been discovered which can serve as substitutes for the anilines in this regard. And how much assistance these dyes have rendered to the study of the structure and even the function of cells! If we trace to their source the discovery of Röntgen's rays, which have found their chief practical application in medicine and surgery, we shall find an illustration scarcely less striking.

No important generalization in physical science is without its influence, often most important, upon biological conceptions and knowledge. I have already referred to the great principles of conservation of mass and of energy which are at the very foundation of our understanding of vital phenomena. Although we can not now foresee their bearings, we may be sure that the new theories, regarding the constitution of what has hitherto been called matter, will, as they are further developed, prove of the highest significance to our conceptions of the organic as well as of the inorganic world. Clerk Maxwell in his article on the atom in the ninth edition of the Encyclopædia Britannica, on the basis of a computation of the number of molecules in the smallest organized particle visible under the microscope, reached a conclusion which he states in these words:

> **Molecular science . . . forbids the physiologist from imagining that structural details of infinitely small dimensions can furnish an explanation of the infinite variety which exists in the properties and functions of the most minute organism.**

Larmor, in the tenth edition of the same work in his article on the ether, points out that upon the assumption of either vortex atoms or electric atoms physical science is concerned only with the atmosphere of the atom, that is with the modification impressed on the surrounding ether, whereas the nucleus or core of the atom may perhaps be taken into account in the problems of biology, although it would appear that nothing can be known of this nucleus. With still later developments of the dynamical hypothesis, which resolves matter into nothing but activity or energy, there are those who think that the hard knot of ages is to be untied and the animate and inanimate worlds come together under a satisfying monistic view of the whole as in essence active energy.

The ultimate problems of biology reside in the cell. Whatever the

future may hold in store, at the present day only a relatively small part of these problems are approachable by physical or chemical methods, and the day is far distant, if it ever comes, when cellular physiology shall be nothing but applied physics and chemistry. We can not foresee a time when purely observational and descriptive biological studies, which to-day hold the first place, shall not continue to have their value. They represent the direction which makes the strongest appeal to the great majority of naturalists. The broadest generalizations hitherto attained in biology, the doctrine of the cell as the vital unit and the theory of organic evolution, have come from this biological, as distinguished from physical, direction of investigating living organisms, and were reached by men with the type of mind of the pure naturalist, who loves the study of forms, colors, habits, adaptations, inheritances of living beings.

It is well that the sciences of nature hold out attractions to so many different types of mind, for the edifice of science is built of material which must be drawn from many sources. A quarry opened in the interest of one enriches all of these sciences. The deeper we can lay the foundations and penetrate into the nature of things, the closer are the workers drawn together, the clearer becomes their community of purpose, and the more significant to the welfare of mankind the upbuilding of natural knowledge.

MEDICINE AND THE UNIVERSITY[1]

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I believe that I make no mistake in assuming that the honor of the invitation to deliver this address came to me mainly through the official position which I chance to hold in the Association for the Advancement of Science and the desire to give prominence on this occasion to the sciences of nature in view of the approaching meeting of the association in this place. I must, however, disclaim any especial competence to speak for these sciences, and I know not where there is less need in our country of emphasizing the importance and significance of the natural and physical sciences, or where the representatives of these sciences have brought higher distinction to themselves and to their university, than here in the University of Chicago.

The past century is memorable above all others for the gigantic progress of the natural and physical sciences—a progress which has influenced more profoundly the lives and thought, the position and prospects of mankind, than all the political changes, all the conquests, all the codes and legislation. In this marvelous scientific advancement in all directions the sciences of living beings and their manifestations have progressed as rapidly and have influenced the material, intellectual and social conditions of mankind as much as the sciences of inanimate matter and its energies. So far as the happiness of human beings is concerned, there is no other gift of science comparable to the increased power acquired by medicine to annul or lessen physical suffering and to restrain the spread of pestilential diseases, although what has been accomplished in this direction is small indeed in comparison with what remains to be achieved. Man's power over disease advances with increased knowledge of the nature and causes of disease, and this increase of knowledge has its sources in the educational system.

In asking your attention on this occasion to some of the conditions and problems of medical education and research, particularly in their

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relation to the university and to circumstances existing in this country, I am aware that the theme is trite and that I can add little that is new to its discussion, but the subject, however wearisome, requires ever renewed consideration so long as the conditions remain as unsatisfactory as at present and so many problems await final solution. Especially is it important that the nature of the problems should be realized by the teachers and authorities of our universities. I know that in this university much earnest thought has been given to questions of medical education, and wisely so, for I have every confidence that the medical department of this university, already doing such good work, is destined to be a leader in the promotion of higher medical education and the advancement of medical knowledge on this continent.

The historical and the proper home of the medical school is the university, of which it should be an integral part coordinate with the other faculties. Before there was a faculty of law at Bologna or of theology at Paris there was a school of medicine at Salernum, which, as is well known, occupies an interesting and unique position in the history of the origin and development of universities. From this early period to the present day no other type of medical school has existed on the continent of Europe than that of the university, and this union has been of mutual advantage, the renown of many universities being due in large part to their medical faculties, and these receiving the fostering care and the ideals of the university.

It was under the influence of these sound traditions of the proper relation of medical teaching to the universities that the first medical schools in this country were founded, that of the College of Philadelphia, now the University of Pennsylvania, in 1765; that of Kings College, now Columbia University, in 1767, and after somewhat longer intervals those of Harvard, Dartmouth and Yale. The model for these early schools was the medical department of the University of Edinburgh, which derived its traditions from the University of Leyden, as these in turn can be traced back to the great Italian universities of the sixteenth century. We can contemplate with much pride and satisfaction the early history of these first American medical schools, which, notwithstanding their feeble resources, were imbued with a spirit of high purpose and just recognition of the qualifications needed for the pursuit of medicine as a learned profession.

It is deeply to be regretted that their successors did not continue

to build on such foundations as those laid by John Morgan, William Shippen and Samuel Bard, but rather adopted and carried much further the plan of the proprietary medical schools which originated in England in the latter part of the eighteenth century and attained their highest development there during the first three decades of the following century, after which the hospital medical schools of a type peculiar to that country gained the ascendancy. We can transfer from our shoulders, however, only a minor part of the responsibility for the conception and establishment of the proprietary medical school, for the English form of this school was a harmless thing which never dreamed of conferring the doctor's degree and was regarded with disfavor by examining and licensing bodies.

The proprietary medical school, conducted for gain, divorced from any connection with a university and free from any responsible outside control whatever, empowered by the state to usurp the university's right of conferring the doctor's degree and at liberty to set whatever standards it chose for obtaining this degree, which carried with it the license to practise, is a phenomenon unique in the history of education and a contribution to systems of education for which America is entitled to the sole credit. This is the type of medical school which prevailed in this country during the greater part of the nineteenth century, and familiarity has made it difficult for us fully to realize how anomalous and monstrous it really is. Even in the case of those schools which were united with a college or university the connection became in most instances so loosened as to be merely nominal and to secure practical autonomy to the medical school. In the common type of these schools there was no requirement of preliminary study worthy of the name, the only practical training was in the dissecting room and an occasional amphitheater clinic, and the degree and license to practise followed the passing of an easy examination after attendance on two annual courses of lectures lasting five or six months each, sometimes an even shorter period, the student hearing the same lectures each year.

It is needless to say that such conditions brought great reproach to American medicine and introduced evils from which we are not yet wholly free. Nevertheless, the system, bad as it was, can be painted in too dark colors. The rapid multiplication of medical schools which followed the second decade of the last century was, although excessive, in response to the needs of a rapidly developing country pushing the

boundaries of civilization ever westward. Still it would be difficult to find a sound argument for increasing the hardships of frontier settlements and struggling communities by a supply of poor doctors.

The main relief to the picture is that the results were not so bad as the system. Many of the teachers were devoted, able men who imparted sound professional traditions and whose personality in a measure remedied the defects of the system. The native force, ability and zeal of many students enabled them to overcome serious obstacles and to acquire in the course of time, in spite of adverse circumstances, a mastery of their calling, perhaps a resourcefulness engendered by these circumstances, for even under the best conditions education does not end with the modicum of knowledge imparted in school and college. Some were so fortunate as to be able to supplement their inadequate training by European study. But among those without foreign training who were entirely the products of American conditions not a few were the peers of their European contemporaries, such as Daniel Drake, Jacob Bigelow, John D. Godman, William Beaumont, Nathan Smith Davis, Samuel D. Gross, Austin Flint, Marion Sims and others who have left names illustrious in the annals of our profession. Native vigor and resourcefulness enabled such men to surmount defects of an educational environment to which the average man must succumb.

Most gratifying is the rapidity with which medical education has risen during the last two decades from the low estate to which it had sunk during the greater part of the past century in this country. Among the more important causes contributing to this result may be mentioned the operation of laws transferring and, in fact, restoring the licensure to practise from the medical schools to state boards of examiners, whereby worthless medical schools are crowded to the wall and out of existence and others have been compelled to raise their standards, the moral pressure exerted through an awakened sentiment for reform on the part of the organized profession and the better schools, closer union between medical school and university and the consequent interest of university teachers and authorities in the problems of medical education, the example set by a few schools of a high order, endowment—although very inadequate—of medical education, which formerly was almost wholly neglected as an object in need or worthy of private or public beneficence, the advancement of medical science and art, necessitating improved methods and higher standards of professional train-

ing, and a juster and wider appreciation of the significance of curative and preventive medicine to the welfare of the community.

The history of medical education in America is still in the making, but we now have a number of schools with high standards and adequate equipment capable of giving to students of medicine a professional education as good as that to be obtained in European universities. The best and most progressive schools are those in organic union with a university, and it seems clear that to schools of this type belongs the future of higher medical education in this country. Nearly twenty years ago in an address at Yale University I endeavored to set forth the advantages of the union of medical school and university, and, as addresses, fortunately for those in the habit of giving them, are soon forgotten, I shall here summarize what I conceive to be the more prominent of these advantages.

Of all professional and technical schools the medical, with its requirements for laboratories, hospitals and teaching force, is the most costly. A medical department of a university is much more likely to be the recipient of endowment funds than an independent school, and the university is a safer and more suitable custodian of such funds.

In manifold ways the environment of a university is that best adapted to the teaching and the advancement of medicine. The medical school needs the ideals of the university in maintaining the dignity of its high calling, in laying a broad foundation for professional study, in applying correct educational principles in the arrangement of the curriculum and in methods of instruction, in assigning the proper place and share to the scientific and the practical studies, in giving due emphasis to both the teaching and the investigating sides of its work, in stimulating productive research, and in determining what shall be the qualifications of its teachers and of the recipients of its degree. Most invigorating is the contact of medical teachers and investigators with workers in those sciences on which medicine is dependent—chemistry, physics and biology.

In the selection of teachers—a matter of the first importance—a university is in a superior position to secure the best available men wherever they can be found, regardless of any other consideration than fitness. Too often this choice has been determined in our medical schools by irrelevant influences and considerations and an outlook upon the world scarcely more than parochial in extent.

In the difficult matter of adjustment of professional training to conditions of collegiate education peculiar to our country there are manifest advantages in the union of medical school with university, especially where the periods of liberal and of professional study are made to overlap. Where the sciences adjuvant to medicine, as general chemistry, physics, zoology and botany, are included in the medical curriculum, as is done in the German and French universities, it is economical and highly desirable that they should be taught in the collegiate or philosophical faculty rather than that separate provision should be made for them in the medical faculty, where they do not properly belong.

The benefits of union of medical school and university are reciprocal, and not to the medical school alone. A good medical faculty, properly supported and equipped, is a source of strength and of renown to the university possessing it, and its work in training students and in extending the boundaries of knowledge greatly increases the usefulness of the university to the community. Nor is there anything in this work which does not appertain to the proper functions of a university, however high its ideals. Indeed I venture to assert that the present and prospective state of medicine and its relations to the well-being of individual man and of human society are such that there is no higher or nobler function of a university than the teaching of the nature of disease and how it may be cured and prevented, and the advancement of the knowledge on which this conquest of disease depends. If it be said that the medical art is largely empiric, I reply that this, while true, does not make medicine unworthy of shelter in the university. The empiric method of discovery by trial and error has its glorious triumphs as well as the scientific and is not to be disdained. To it we owe such beneficial discoveries as the curative properties of quinine in malaria, vaccination against smallpox and the anesthetic uses of ether and chloroform.

But there is a scientific as well as an empiric side to medicine and the distinctive feature of modern medicine is the rapid extension of the former and the curtailment of the latter. The fundamental medical sciences—anatomy, physiology, physiological chemistry, pathology, pharmacology, bacteriology and hygiene—are rapidly advancing and important departments of biological science, which have contributed and will continue to contribute enormously to the progress of practical medicine. In an address which I had the honor to deliver somewhat over

ten years ago at the dedication of the Hull Biological Laboratories of this university I took occasion to dwell with some detail upon the biological aspects of medicine.

We should add to the specialized medical sciences already mentioned the study of the problems presented by the living patient in hospitals and laboratories attached to hospital clinics where chemical, physical and biological methods can be applied to the investigation of clinical problems, which do not fall within the scope of other laboratories or can be less advantageously attacked in them. These clinical investigating laboratories are an important addition to the older analytical and statistical methods of study of disease and mark an advance from which valuable results have been obtained and more valuable ones are to be expected. It is highly desirable that our medical clinics should be organized with regard to this newer direction of work, for which they will require considerable funds.

The science of medicine has advanced in recent years more rapidly than the art and in its various branches it constitutes to-day a field of work most alluring and most rewarding to the properly trained scientific investigator, who, if he have the rare genius for discovery, may reap a harvest rich in blessing to mankind.

But the art of medicine has profited greatly by the application of scientific discoveries. The physician and the surgeon to-day can do far more in the relief of physical suffering and in the successful treatment of disease and injury than was formerly possible, but the great triumphs have been in the field of preventive medicine. The horizon of the average man's interest in medicine scarcely extends beyond the circumference of his own body or that of his family, and he measures the value of the medical art by its capacity to cure his cold, his rheumatism, his dyspepsia, his neurasthenia, all unconscious, because he does not encounter them, of the many perils which medicine has removed from his path through life. What does he know of the decline in the death rate by one half and of the increase in the expectation of life by ten or twelve years during the last century? How many are there whose attention has been called to the significant fact that this increase in the expectation of life ceases with the forty-fifth year because we have as yet no such insight into the causes and prevention of the organic diseases of advancing life as we have into the manner of propagation of infectious diseases, which are responsible for the larger part of the mortality

of the earlier years? The suffering and the waste of energy, money, production and human lives from preventable sickness and death are still incalculable, but how little heed do legislators and authorities in our national, state and municipal governments pay to the appeals of physicians and enlightened economists to make adequate provision to check this waste! For this condition of things the medical profession is largely responsible in failing to enlighten the public and in shrouding its art with the mystery of an occult science, but it is beginning to rise to its high mission of public education in ways of preserving health and of preventing disease.

I have touched on these matters relating to the present and future state of the science and art of medicine, not with the view of recounting the achievements of modern medicine, but to indicate something of their importance to individual and to civic life and to show that in fostering the teaching and study of medicine the university finds a field worthy of its highest endeavors in the propagation of useful knowledge and in service to the community.

From what has been said we may, I think, assume with confidence that the best and in time the prevailing type of American medical school is destined to be that represented in medical departments in vital union with universities. In so far our system of medical education will conform to that of Germany and France, but in an important respect there is and will doubtless remain a difference due to the fact that in those countries the courses of study and the qualifications for the degree and the license to practise are molded into practical uniformity by the regulations of the state. Nothing is more characteristic of the conditions of medical education in our country than the great diversity of the requirements and curricula of the various medical schools, even of those of the better sort. Entire uniformity is not to be expected and not to be desired, but at least such a measure of agreement should be secured as will permit students to pass freely from one university to another and to acquire, it is to be hoped, something of the habit of wandering which is such an enviable feature of student life in the German universities.

No problem of medical education in this country is so perplexing or has given rise in recent years to so much discussion and difference of opinion as that of the preliminary education to be required for the study of medicine. If I could announce a universally satisfactory solution

of this problem, I should claim the honors of an important discovery, but as I can not do so I shall forego on this occasion its detailed discussion, with a self-sacrificing forbearance which I trust may be commended by my hearers. It must suffice to enumerate the attempts at a solution, premising, what is generally recognized, that the difficulties arise from the anomalous development of the American college for many years, making it, however admirable it may be for certain educational uses, almost unadjustable to the needs of professional education.

The preliminary requirement of the bachelor's degree in arts or science should, in my judgment, carry with it the specification of collegiate laboratory training in physics, chemistry and biology, with a reading knowledge of French and German. These requirements have been in successful operation in the medical department of the Johns Hopkins University since its foundation in 1893, their adoption being necessitated by the acceptance of the terms of Miss Garrett's gift of endowment. We are satisfied with the working of these requirements and would not lower them if we could, but it must be conceded that, while there is room for medical schools with these standards, the country is not ripe for their general adoption. The medical department of Cornell University has recently announced the intention to introduce similar requirements, and the Harvard University Medical School demands the bachelor's degree without the other requirements mentioned.

In order to meet the objection that the average age of graduation from our colleges is at least two years beyond that at which professional study usually begins in Europe, various attempts have been made to truncate the college course or to telescope a quarter to a half of it into the period of professional study, making one course of study count for two degrees. Manifest objections and embarrassments attend all of these attempts to find a suitable stopping place between the high school and the end of the college course. The plan adopted in this university to demarcate with some sharpness the first two years of the college course from the remainder and to exact the completion of these two years of study as the requirement preliminary to the study of medicine has much to recommend it under existing conditions. I learn from the last report of the Council on Medical Education of the American Medical Association that one medical school, the medical department of Western Reserve University, demands as a prerequisite to the study of

medicine three years of study in a college of arts or science, sixteen require two years of collegiate study, eleven of these schools being in the middle west or west, and thirty-one require one year, of these, nineteen being in the middle west or west.

The Council on Medical Education just mentioned, of which Dr. Bevan is the energetic and efficient chairman, has entered as a strong force for the elevation of standards of medical education in this country, and, while it has not the power of the British General Medical Council to make effective its recommendations, it can exert a most beneficial influence. It is significant that at its first conference, held in 1905, it recommended as the minimum preliminary requirement to be generally adopted by our medical schools an education sufficient to enable the student to enter the freshman class of a recognized college of arts or a university, and now it recommends that in 1910 to this shall be added a year's study of physics, chemistry and biology, with one modern language, preferably German. The time has gone by when it is necessary to emphasize before an audience such as this the importance of laboratory training in physics, chemistry and general biology as fundamental to the successful study of medicine.

While it is not feasible to exact the preliminary study of the ancient classics, save some acquaintance with Latin, I feel that they are of value to the physician and that a liberal education and broad culture raise the influence and standing of the physician in the community, enhance and widen the intellectual pleasures of his life, instil an interest in the history of medicine and give him greater joy in the pursuit of a noble profession. It is important, especially for medicine, that this culture be imparted by methods of liberal education which do not blunt man's innate curiosity for the facts of nature.

There can be no more striking evidence of the progress of medical education in this country during the last quarter of a century than that it is no longer the laboratory, but the clinical side of medical teaching which offers the urgent problems. Only a few years ago the cry was the need of laboratories; now, while a sufficient supply of good laboratories is still beyond the resources of many medical schools, their value is fully recognized and all of our better schools possess them and are devoting probably as much of the time and energies of teachers and students to work in the laboratories as is desirable. There is even some risk, I believe, that a subject which can be studied with facility

and advantage in a laboratory may acquire, on this account, a position in the scheme of medical studies disproportionate to its relative importance. The structure of organized beings, normal or diseased, for example, is eminently adapted to laboratory study, and for centuries normal anatomy had an educational value all its own, because it was the only subject which students were taught in the laboratory, whereas the study of function, certainly not less important, is much more difficult to approach by the laboratory method, and even at the present time normal physiology and especially pathological physiology do not receive the attention in medical education to which their importance entitles them.

It is interesting to note the impressions which Professor Orth, of Berlin, an acute observer and most competent judge in all matters pertaining to medical education, received from his visit to this country three years ago regarding our laboratories and clinics. In an address conveying these impressions to the Berlin Medical Society he expresses his astonishment and satisfaction that, in contrast to the prevalent opinion in Germany as to our medical schools, he found that fully as much emphasis is placed on laboratory teaching here as there, that the laboratories which he visited are as good, their arrangements in some instances arousing his envy, and the methods of teaching practically the same as in Germany, whereas he gathered the impression that the opportunities and methods of clinical teaching are less satisfactory than in Germany and not commensurate with those of our laboratories.

I do not desire to instil sentiments of undue complacency regarding the condition of laboratory teaching in our medical schools, for there is still room for much improvement in this regard. Many schools are sadly deficient and even the best have not all that is needed in the supply and maintenance of laboratories, but the time has come to give especial emphasis to directions of improvement in the teaching of practical medicine and surgery. The making of good practitioners should always be kept to the front as the prime purpose of a medical school.

I believe that in most medical schools at present the clinic falls behind the laboratory in affording students opportunities for that prolonged, intimate, personal contact with the object of study, in this instance the living patient, which is essential for a really vital knowledge of a subject. To secure this, amphitheater clinics and ward classes alone do not suffice, valuable as these are, but students under suitable

restrictions and supervision and at the proper period in their course of study should work in the dispensary and should have free access to patients in the public wards of hospitals, acting in the capacity of clinical clerks and surgical dressers as a part of the regular, orderly machinery of the hospital.

In order to place the clinical side of medical instruction on the same satisfactory foundation as that of laboratory teaching, two reforms are especially needed in most of our medical schools.

The first is that the heads of the principal clinical departments, particularly the medical and the surgical, should devote their main energies and time to their hospital work and to teaching and investigating without the necessity of seeking their livelihood in a busy outside practise and without allowing such practise to become their chief professional occupation. This direction of reform has been forcibly urged in this city and elsewhere by my colleague, Dr. Barker, whom we have reclaimed from you, in notable papers and addresses.

The other reform is the introduction of the system of practical training of students in the hospital, which I have indicated, and with it the foundation and support of teaching and investigating laboratories connected with the clinics, to which I have already referred, necessitating the possession of a hospital by the medical school or the establishment of such relations with outside hospitals as will make possible these conditions. This subject, as thus outlined, I made the theme of an address at the opening, six months ago, of the new Jefferson Medical College Hospital in Philadelphia, and I shall now recur only to the point which I endeavored there to establish, that the teaching hospital subserves the interest of the patient not less than that of the student and teacher and is the best and most useful kind of public hospital.

Hospitals make generally a stronger appeal to public and private philanthropy than the support of medical education, but I do not hesitate to affirm that a general hospital in a university city, whether maintained by public funds or by private benevolence, serves the community and the interests of its patients far better when it is readily accessible and freely available for the purposes of medical education than when it is divorced from connection with medical teaching. Witness the great public hospitals in Vienna, Berlin, Munich, Leipsic, Paris, London, Edinburgh, Dublin and a few in this country. It is most

deplorable both for the hospitals and for the medical schools that these two institutions, which should be linked arms of medical education, should have developed in this country so far apart, that state and municipal authorities and private founders should have so little realization of the inestimable advantages which close association with a good medical school can confer on a hospital, and that the immense possibilities of public hospitals in our large cities for the education of students and physicians and for the advancement of medical knowledge should be utilized to so small an extent, often not at all.

It would be one of the greatest benefits to the cause of higher medical education if the University of Chicago, for its medical department, should come into possession of a good general hospital and fortunate the hospital which enters into this relationship. This university, the source of so many important contributions to the advancement of knowledge and of higher education, will then be, in larger measure than it now finds possible, a center of similar service to medicine.

Medical education partakes fully of the freedom, so amazing often to many of our European colleagues, with which we unhesitatingly try all sorts of educational experiments in this country—it is to be hoped and expected for the ultimate benefit of systems of education, whatever the immediate results may be in individual cases. The theme of this address naturally suggests many topics relating to methods of teaching and to the medical curriculum which are questions of the day, but which I must lay aside through lack of time. On one only I beg to say a few words.

In contrast to the German system, the tendency in our American medical schools has been toward a rigid curriculum, which, though widely divergent in different schools, is to be followed in precisely the same way by all students without any consideration of differing ability, capacity for work, special aptitudes and interests. One of many unfortunate results is that subjects and courses of study which can not properly be imposed as obligatory on already overburdened students find no place in our medical schools, which should aim to cultivate the whole field of medicine. I agree with Dr. Bowditch and my colleague, Dr. Mall, to whose admirable presentation of this subject I would refer those interested, that our students should have a greater latitude of choice than is now customary in subjects to be pursued, in the amount of time to be devoted to their study and in the order in

which they may be taken. Complete freedom can not be granted. A minimum requirement for the principal subjects must be made obligatory, but if this minimum is properly fixed there remains room for a considerable range of choice of subjects and courses, greatly to the advantage of student and teacher. At the Harvard Medical School the system of electives for the fourth year of the course has been in operation for several years, and other medical schools have also introduced a similar plan. At the beginning of the current academic year we adopted at the Johns Hopkins Medical School a scheme by which a large number of elective courses are offered throughout the four years, and the plan is now working most successfully.

Some of our state boards of examiners are greatly exercised over the differences which they find in the curricula of the various medical schools in this country, and which in themselves are merely an indication that there is, and, in my judgment, there can be no agreement of opinion as to every detail of a medical curriculum. There are doubtless defects to be remedied, but in attempting to apply remedies these state boards should concern themselves with no other question than that of educational standards. They could make no greater mistake nor inflict more serious injury on the efforts of the better schools to improve their methods of teaching than to attempt to impose a uniform and rigid obligatory curriculum on all schools. They do not in their examinations apply any practical tests whatever to determine the candidate's fitness for the practise of medicine, whereas our better schools are exerting every effort to increase their efficiency by substituting practical work in laboratories, hospital wards and out-patient departments for didactic lectures. The work of students who gain their knowledge by serving as clinical clerks and surgical dressers in the hospital can not be measured by time standards in the same precise way as that of attendance on expository lectures. Above all, the better schools should not be hampered by restrictions imposed by state boards of examiners in freedom to extend the system of electives of which I have spoken.

The medical department of a university should be a school of thought, as well as a school of teaching, *academia* as well as *schola*. Although there has been gratifying progress in recent years, our medical schools have not advanced along the path of productive research to the same extent that they have in the way of improvement of their educational work. There are several reasons for this condition. For one

thing we have been too busy setting our houses in order for their primary uses in the training of students to have given the requisite attention to other questions which, however important, may have seemed for the moment less urgent. With the degree of emphasis thus placed on the educational side teaching gifts rather than investigating capacity have been sought as the most desirable qualification of professors in our medical schools. The power of imparting knowledge, gained second-hand, fluently and even skilfully, is not an uncommon gift and is possessed by many who have never engaged in research and have no especial inclination or aptitude for it, but the teaching of him who has questioned Nature and received her answers has often, and I think commonly, in spite it may be of defects of delivery, a rarer and more inspiring quality.

A medical school or university can not expect to fill all of its chairs with men with the genius for discovery—if it has one or two it has a treasure beyond all price—but every effort should be made to secure as occupants of these chairs from among those who are available, wherever they can be found, the ones who have demonstrated the greatest capacity to advance knowledge by original investigation and the ability to stimulate research. Until this principle is more fully and generally recognized and acted on in the selection of heads of departments, our medical schools as a class will not become important contributors to knowledge. It is not enough that a few schools should encourage and provide for original investigation; the field must be a wide one in order to attract many to a scientific career, for of the many only a few will be found endowed with the power of discovery. There is no possible way of recognizing the possessor of this power before he has demonstrated it. Even when a university has succeeded in attaching to it those who can conduct scientific inquiry successfully, how often are their energies sapped by lack of adequate resources and enough trained assistants and by too great burden of teaching and administrative work imposed on them!

It is evident from what has been said, and indeed it has been a tacit assumption throughout this address, that, while with present resources considerable improvement in medical education in this country is possible, further progress is largely a question of ways and means. What makes modern medical education so costly is precisely its practical character, necessitating laboratories and hospitals, and it can be made

self-supporting no more than any other department of higher education. For reasons already stated, the medical departments of strong universities are the ones most likely to receive the funds needed for the support of medical education and are in general the most deserving. There is a great future before the medical schools of many of our state universities, which are already developing with such promise and are sure to receive in increasing measure aid from the state as their needs and the benefits accruing to the community from their generous support are more and more fully appreciated. Other universities must look to private endowment, and I have endeavored to show that they should foster their departments of medicine as zealously as their other faculties. The university chest should be opened, so far as possible, to supply needs of the medical school, and authorities of the university should present the claims of medical education to financial aid as among the most important in their domain, and they can do so to-day with a force of appeal not possible a quarter of a century ago. President Eliot, whose services to the cause of medical education are great, in his address at the opening of the new buildings of the Harvard University Medical School, set forth with admirable force and clearness the changes which advancing medicine has brought in the vocation of the physician, his greatly increased capacity of service to the community and his still higher mission in the future.

The discoveries which have transformed the face of modern medicine have been in the field of infectious diseases, and in no other department of medicine could new knowledge have meant so much to mankind, for the infectious diseases have a significance to the race possessed by no other class of disease and problems relating to their restraint are scarcely less social and economic than medical. The public is awakening to this aspect in the case of tuberculosis, and I need only cite as a further example the necessity of keeping in check the malarial diseases and yellow fever for success in digging the Isthmian Canal, an undertaking in which the triumphs of the sanitarian, Colonel Gorgas, are not outrivaled by those of the engineer. Such victories over disease as those of the prevention of hydrophobia by the inoculation of Pasteur's vaccine and the antitoxic treatment of diphtheria have made an especially strong impression on the public mind.

More than all that had gone before in the history of medicine the results achieved during the last quarter of a century in exploration of

the fields of infection and immunity opened by the discoveries of Pasteur and of Koch have stirred men's minds to the importance of advancement of medical knowledge, and medical science at last has entered into its long awaited heritage as a worthy and rewarding object of public and private endowment. But it is to be noted that it is not so much the education of doctors as this advancement of knowledge which makes the strong appeal, as may be illustrated by the splendid foundation of the Rockefeller Institute for Medical Research through the enlightened generosity of the founder of this university, the Phipps Institute for the Study and Prevention of Tuberculosis, and the Memorial Institute for the Study of Infectious Diseases, established in this city by Mr. and Mrs. Harold McCormick, which under the efficient direction of Dr. Hektoen has become a most active and important contributor to our knowledge of infection and immunity.

These magnificent additions to the resources of this country for the promotion of medical investigations are of inestimable value, but not one of them could have justified its existence by results if it had been established in America thirty years ago, when medical education was so defective. The dependence of research on education is of fundamental importance. The prime factor influencing the development of scientific research in any country is the condition of its higher education. Scientific investigation is the fruit of a tree which has its roots in the educational system, and if the roots are neglected and unhealthy there will be no fruit. Trained investigators are bred in educational institutions. Independent laboratories are dependent on a supply from this source, and without it they can not justify their existence, but where proper standards of education exist such laboratories have a distinctive and important field of usefulness. I contend, therefore, that those interested in the advancement of medical knowledge should not be indifferent to the condition of education in our better medical schools and should not rest on the assumption that the educational side can be safely left to take care of itself.

Moreover, those who are to apply the new knowledge are physicians and sanitarians. The public is vitally interested in the supply of good physicians, never so much as to-day when their power to serve the welfare of the community has been so vastly increased and is rapidly growing, and if it wants good doctors it must help to make them.

I have been able, within the limits of this address, to indicate only a

relatively small part of the increased strength gained by both medical school and university by the combination of their forces, but I hope that I may have conveyed some impression of the rich fields of discovery, of the beneficent service to the community, of the important educational work opened to the university by close union with a strong department of medicine, and of the inestimable value to medicine of intimate contact with the fructifying influences and vitalizing ideals of the university. Where is there a university which, if provided with the requisite resources, gives stronger assurance of securing these mutual benefits than the University of Chicago, so fruitful in achievement during its brief but eventful history, so vigorous in its present life, so full of high promise for the future, and where in all this land is there a location more favorable to the development of a great university medical school than here in the city of Chicago? Such a development is bound to come and the sooner it arrives the earlier the day when America shall assume that leading position in the world of medical science and art assured to her by her resources, the intelligence of her people, her rank among the nations and her high destiny.

THE RELATION OF THE HOSPITAL TO MEDICAL EDUCATION AND RESEARCH[1]

By William H. Welch, M.D., LL.D.,
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The most urgent need of the medical schools of this country at the present time is the possession of well-organized and well-equipped hospitals, available for teaching, and I esteem it a great privilege to bring greetings and congratulations to the Jefferson Medical College on this splendid addition to its educational resources. Coming, as so many of us do, directly from the meeting of the American Medical Association in Atlantic City, my colleagues, representing the medical profession of this country, will surely be glad to have me express on this happy occasion in their behalf congratulations to this college and to this city. We must all rejoice in the enlarged opportunities for bedside teaching supplied by this fine hospital to the Jefferson Medical College, which from its foundation over eighty years ago has laid especial emphasis on clinical instruction, which has sent forth so many graduates who have achieved professional success and eminence, and which has possessed such distinguished teachers and ornaments of our profession as McClellan, Eberle, Dunglison, Bache, Drake, Meigs, J. K. Mitchell, Dickson, Pancoast, Mütter, the Grosses, Brinton, Da Costa, whose worthy, living successors will not deem it invidious if I add to this incomplete list the name of that leader of American surgery, their absent colleague, Keen, who, resting from his many years of brilliant and successful work in behalf of this college, will in a distant land be glad with us to-day.

The Jefferson Medical College is indeed singularly fortunate in the possession of this large general hospital, admirable in construction and arrangement, entirely under the administration of a single board of trustees common to the college and the hospital, who control all of the appointments to the hospital staff and who in serving the best interests

[1] Address at the opening of the new Jefferson Medical College Hospital, June 7, 1907. Published in *The Journal of the American Medical Association*, August 17, 1907.

of the patients are in the fullest sympathy with the needs of medical education and active in its promotion. It is precisely the lack of hospitals under the control of our medical schools which constitutes one of the most serious obstacles in the development of medical education in this country, and all interested in the advancement of medical science and teaching in America have reason to be grateful to the State of Pennsylvania and the private benefactors whose enlightened generosity has made possible this enviable possession of the Jefferson Medical College.

The theme of my remarks on this occasion—the relation of the hospital to medical education and medical research—is naturally suggested by the event which we are assembled to celebrate.

The discussion of the problems of clinical teaching and investigation by one engaged in laboratory work, although actively interested in all that pertains to the advancement of medical education, may have the advantage, so useful to a speaker, of a certain detachment of view, of length, if not clearness, of perspective, and of the absence of too disturbing a consciousness of all the difficulties inherent in the working out of details.

It would be interesting to trace the evolution of methods of clinical instruction from their inception, or rather revival, in Padua by Montanus about the middle of the sixteenth century to the present time. We should follow the conveyance of these methods by the elder van Heurne toward the end of the sixteenth century from Padua to Leyden, where in the course of a century they reached the high development attained under the great Boerhaave, *communis Europæ preceptor,* and whence influences, spreading in the eighteenth century first to Göttingen, Halle, Vienna, and Edinburgh, can be traced continuously down to this very day and to the medical schools of America. But such a historical survey, hitherto imperfectly drawn, is a theme by itself, which I must forego, although commending it as an attractive one to medical historians.

While the early history of medical education in this country is a story of feeble resources, but still of high endeavor and of just appreciation of the requirements of training for a learned profession, we can not contemplate with similar satisfaction and pride the deplorable period which followed through many years of lowered standards of preliminary education, of shortened courses, and of faulty arrangement of the cur-

riculum. Nevertheless, these unfortunate conditions, attributable mainly to the circumstances of rapid, pioneer development of the country and to the absence of any responsible supervision outside of the medical schools, were saved from giving results as bad as they are often depicted and as the system seemed to demand by a measure of practical, clinical instruction, by the high character and gifts of many of the teachers, and by the preservation of sound traditions of the physician's calling.

Nothing is more remarkable in the history of medical education in this country than the rapidity with which our better schools have emerged in the last two decades from this low state. Especially noteworthy during this period is the development in these schools of laboratory teaching from the weakest to the strongest position in the curriculum, with the corresponding and most gratifying growth in this country of the sciences of anatomy, physiology, pathology, biologic chemistry, pharmacology and bacteriology. Hygiene, unfortunately, has lagged behind, mainly, I believe, through lack of careers for trained hygienists in this country, especially on our boards of health.

The introduction and development of laboratory teaching has had a profound influence on our ideas of methods of medical education. In the laboratory knowledge is acquired not by reading or being told about things or even by seeing them demonstrated by another, but by immediate contact with the object of study, by power to use technical instruments and procedures, and by personal observation and experiment. A final adjustment has not yet been reached between this practical method of acquiring knowledge and the older didactic or expository method, to which within proper restraints I am not unfriendly, but the days of dominance of didactic teaching in our medical schools are numbered.

A pertinent inquiry in this connection is whether improvement in the teaching of medicine and surgery has kept pace with that of the laboratory subjects. Improvement in the former there has been, but it is, nevertheless, true that the so-called theoretical subjects are to-day taught most practically and the so-called practical branches most theoretically. It is above all familiarity with the methods and results of teaching in the laboratory which has emphasized this contrast and has indicated directions of improvement. Such contrasts, however, as those implied in the distinctions so commonly drawn between theoretical or

scientific subjects on the one hand and practical subjects on the other in the medical curriculum, and between the methods of teaching in the laboratory and those of teaching in the hospital are unfortunate and not inherent in the nature of the subjects. Both classes of subjects are practical in that they admit of application to practical use and in that their common aim is to serve the training of practitioners, and both are scientific in that they rest on and are furthered by coordinated knowledge gained by systematic observation, experiment and reasoning. The justification for the presence of any obligatory subject in the medical curriculum and for the amount of time devoted to it is its importance for the training of sound practitioners of medicine and surgery. Nor should there be any difference in the general principles underlying the methods of teaching the laboratory subjects and those of teaching the clinical branches. For the latter the hospital is the laboratory where the results of Nature's experiments are to be studied and alleviated by the methods of science.

Training in the laboratories in the early years of the medical course should be a preparation for the final work in the hospital where the ultimate goal of medical education is approached—the ability to interpret and to forecast, and the power to prevent, to remove or to relieve the manifestations of disease and injury. Important as clinical teaching must have been even in the relatively undeveloped state of medicine and surgery in past centuries, it is vastly more important in these days of accumulated medical knowledge and experience, of refined methods of diagnosis by physical examination and by a multitude of technical procedures, and of improved methods of medical and surgical treatment.

Do the methods of teaching the clinical subjects generally adopted in our medical schools at the present time bring the student sufficiently into that intimate, prolonged, personal contact with the object of study, in this case the living patient, which secures that abiding, vital, useful knowledge, the possession of which alone is power for good, and the lack of which is helplessness and even power for harm? As I have intimated, I believe that the clinic falls behind the laboratory in this regard, and that the greatest strength of the curriculum is not where it should lie.

It is not many years since practically the sole method of clinical teaching in the medical schools of this country was the amphitheater clinic. Not a word need be said against the value of this important

form of clinical instruction, but no argument is needed to show that by itself it does not suffice for the practical training of students in the science and art of medicine.

A distinct advance was marked by the introduction in recent years of the system of ward classes, by which students in groups are admitted to the hospital wards and given opportunities to examine patients and to receive personal instruction. It is not necessary for my present purpose to discuss the various forms of these ward classes or the methods of conducting them, or similar classes for practical, clinical instruction, or to point out in detail their great value to the student, which is universally recognized.

Neither the amphitheater clinic nor the ward class meeting under an instructor at stated hours and for short periods of time, useful as they are, represents the full ideal of the laboratory method of teaching. They correspond rather to demonstrative courses, which have their own place and value. Such courses alone would represent the attempt to teach a subject like bacteriology by demonstrations of methods, cultures and microscopic slides instead of having the student make his own media, plant and cultivate the bacteria by his own hands, and follow and study from day to day with his own eyes the characters of the growing organisms. It is only by the latter method that bacteriologists are made and it is only by a similar method that capable practitioners of medicine and surgery can be made, and if this essential training is not at least begun in the undergraduate days in the medical school, it must be secured, if at all, later, often under disadvantageous circumstances and at great cost both to patient and to physician.

This kind of clinical training means practical work in the dispensary and especially that students in their final year of study have patients assigned to them in the public wards of the hospital, where under proper restrictions they can freely come and go, that they take histories, make necessary examinations for diagnosis, follow the course of disease from day to day and become familiar with methods and results of treatment, all of this work being, of course, under competent supervision and undertaken only after suitable preliminary studies. Privileges and opportunities for practical training of the kind indicated are at present enjoyed in most of our hospitals only by the fortunate internes, but the system is familiar in Great Britain as that of clinical clerks and surgical dressers, and in Germany as that of *Praktikanten*, hospital service in this capacity

being a requirement in these countries for admission to examinations for the license to practise. The system has been in successful operation at the Johns Hopkins Hospital since the opening of the medical school.

It should be emphasized that the system, unlike that of ward classes, constitutes a part of the regular, orderly machinery of the hospital, that the students do work important for the interests of the patient and which, if not done by them, would have to be done by others. How important this kind of clinical training is deemed by that country which has long held the leadership of medical science is indicated by the recent addition in Germany to the formerly required period of study of the so-called practical year of continuous service in a hospital before the student is eligible for the license to practise.

I believe that it is incumbent on our medical schools and public hospitals to furnish students with opportunities for the kind of clinical training which I have briefly sketched and have indicated as comparable to the laboratory method of teaching. Let us briefly consider what objections can be urged against this method of clinical training and what obstacles stand in the way of its general adoption in this country.

The difficulties are not to be sought primarily in the lack of desire or willingness on the part of medical schools to advance along these lines of improved clinical teaching. It may be that the advantages of the newer methods are not so widely and fully appreciated as is to be desired, but the leaders and especially the younger generation of clinical teachers are alive to the importance of reform.

The difficulties and objections come from that other essential arm of medical education—the hospitals. Under the prevailing system of medical education in this country the most valuable asset of a medical school is the possession of an endowed, good general hospital, the appointments to which are controlled by the school and a main purpose of which is to serve the interests of medical education, while serving the best interests of the patients. There are few hospitals which stand in this relation to a medical school and of these still fewer capable of furnishing the requisite clinical opportunities, for it is self-evident that the system of ward work which I have outlined is practicable only when the ratio between the number of patients and the number of students does not fall below certain limits.

Most of our schools must look to outside public hospitals to aid

them in this most important part of the training of medical students, and the appeal of the schools and the students, an appeal which should be supported by the entire medical profession, is one which should receive the most careful consideration from the trustees of these hospitals. The source of the appeal should be heeded. Our medical charities could not exist without the free gift of their services by physicians, and the mere pecuniary value of these services, amounting annually to many millions of dollars, exceeds that of all the funds contributed to their endowment. The welfare of the community is vitally concerned with the supply of well-trained physicians, never so much so as to-day when the power to relieve suffering and to check the incalculable waste to society from preventable disease has been greatly increased and is constantly growing. If the public wants good doctors it must help to make them.

A hospital which includes, as most public hospitals do, among its recognized legitimate functions not only the care of the poor sick, but also the training of physicians and nurses and the advancement and dissemination of medical knowledge, adds no function which is new in principle when it admits advanced undergraduate students to work in its wards, while by so doing it greatly increases its usefulness and service to the community, and I believe also the patients. There is no very material difference between the qualifications of these advanced students to undertake this work and the qualifications of internes when first admitted to the hospital staff. The introduction of these students into the hospital in accordance with the plan of ward work recommended interferes in no way with the orderly discipline and quiet of the wards.

The objection concerning which the greatest misapprehension exists and which doubtless weighs heaviest in the minds of managers of hospitals and of the lay public, unfamiliar with the actual facts, is the fear that harm will be done to the patients by permitting them to be examined by students. The primary purpose of the hospital is, of course, the care and treatment of the patients and the first duty of hospital trustees and physicians is to the patient. Nothing which prejudices the welfare of the patient can for a moment be permitted, and if it were true that the kind of clinical training which I am advocating inflicted any injury whatever on the patient, no other considerations could outweigh this objection.

The objection, however, is entirely unfounded. Every one acquainted with the conditions knows that our clinical teachers and the attending physicians and surgeons of hospitals are keenly solicitous for all that conduces to the comfort of their patients and makes for their recovery, every whit as much so for the poor as for the rich. They can be safely trusted to take every precaution to guard patients from harm and to imbue their students from the start with the same spirit of anxious solicitude for the welfare of the patients. A main purpose of the kind of clinical training under consideration is precisely to teach students when and how to examine patients, and I am informed by my clinical colleagues that students are, if anything, overcautious in their anxiety to refrain from any possibly injurious disturbance of the patient and that they carefully observe any directions which may be given regarding patients. Your own Dr. Keen in his admirable presidential address to the Congress of American Physicians and Surgeons on "The Duties and Responsibilities of the Trustees of Public Medical Institutions" expressed himself on this point of possible harm to the patient from bedside instruction in these forcible words:

> I speak after an experience of nearly forty years as a surgeon to a half-dozen hospitals and can confidently say that I have never known a single patient injured or his chances of recovery lessened by such teaching.

So far from being detrimental, the teaching of physicians and students is distinctly advantageous to a hospital and its patients. The teaching hospital is in general more influential, more widely useful and more productive in contributions to medical knowledge than a hospital not concerned with teaching. Such a hospital is more attractive to physicians and surgeons of distinction and, therefore, more likely to be able to attach such men to its attending staff, and thereby secure the best medical service. The stimulating influence of eager, alert students on the clinical teachers in hospitals has been so delightfully depicted by Dr. Keen in the address just cited, and which should be widely read by trustees and physicians, that I can not refrain from quoting his remarks on this point in full. He says:

> Moreover trustees may overlook one important advantage of a teaching hospital. Who will be least slovenly and careless in his duties, he who prescribes in the solitude of the sick chamber and operates with two or three assistants only, or he whose every movement is eagerly watched by hundreds of eyes, alert to detect every false step, the omission of an important clinical laboratory investigation, the neglect of the careful examination of the back as well as of the front of the chest, the failure to detect any important physical sign or symptom? Who

will be most certain to keep up with the progress of medical science, he who works alone with no one to discover his ignorance; or he who is surrounded by a lot of bright young fellows who have read the last *Lancet* or the newest *Annals of Surgery*, and can trip him up if he is not abreast of the times? I always feel at the Jefferson Hospital as if I were on the run with a pack of lively dogs at my heels. I can not afford to have the youngsters familiar with operations, means of investigation or newer methods of treatment of which I am ignorant. I must perforce study, read, catalogue and remember, or give place to others who will. Students are the best whip and spur I know.

There is no teacher who will not subscribe to these words of Dr. Keen.

It should furthermore be emphasized that the efficiency of the teaching hospital in its main function of treating diseased and injured patients is increased not only by securing the most skilful medical staff, by the constant stimulus of their interest and activity and by the spirit pervading the institution, but also by the participation of advanced students in the work of the dispensary and the wards in accordance with the system of clinical training which I am urging on your attention. When one considers all the time-consuming microscopic, chemical and physical tests applied in modern diagnosis and necessary to secure complete records of cases of disease, it can be readily understood that the increased force of those trained to make these examinations conduces to more accurate diagnosis, and to more satisfactory control of the progress of the patient from day to day, and therefore to better treatment. In advocating improved methods of clinical training and the introduction of such training more generally into public hospitals I plead and plead earnestly for the student, but I plead also for the hospital and the patient.

It is really lamentable to contemplate the immense clinical material which exists in the public hospitals of our large cities and which could be made available for the education of students and physicians and for the advancement of medical knowledge, but which is utilized for these purposes either not at all or very inadequately. Medical schools of these cities do not begin to secure the advantages of location which rightfully belong to them and they allow themselves to be outstripped by schools less favorably situated and the hospitals themselves are less useful than would otherwise be the case.

I am well aware of the practical difficulties in establishing the necessary relations with hospitals not already connected with medical schools. These difficulties, however, are not insurmountable if the trustees,

teachers and medical staff sincerely desire their removal. The new order doubtless involves readjustment of existing conditions both in the schools and in the hospitals concerned. In many instances there will follow a considerable increase of the force of clinical teachers and a wider recognition of work done outside of the college walls and of the immediate direction of members of the faculty, a recognition, it may be, of something on the order of the Scottish extramural teaching or of the German privat-docent system, but adapted to our own special conditions. Careers will be opened to hospital physicians and surgeons, especially to young men, ready and fitted to teach but who now find the doors closed to them.

My remarks thus far have related mainly to the needs of undergraduate medical students and to methods of undergraduate clinical teaching. Education at best is only begun in the school, and the most the medical school can hope to do is to send its graduates forth fitted to begin their professional work and to continue their lifelong education with the greatest advantage to themselves and to others. I have on another occasion discussed the serious lack of opportunities in this country for the training of young men who aim at the higher careers in clinical medicine and surgery, and I contrasted these opportunities with similar ones now open in our laboratories for those who desire to become teachers, investigators or directors of laboratories of anatomy, physiology, pathology or other medical science. Training for the higher clinical careers requires a long apprenticeship after graduation from a medical school and after the ordinary hospital internship and is best secured by prolonged service in a hospital as resident physician or surgeon under conditions which secure more thorough practical experience and better opportunities for scientific study and investigation than those which now exist under the customary arrangement of the medical staff of our hospitals. I shall not now occupy time by renewed consideration of this aspect of my subject further than to state my belief that the reorganization of the resident and interne medical staff of the hospital indicated for this higher training of graduates of medicine is also that best adapted, if not essential, for the successful operation of the system of ward work for undergraduates which I have sketched and for the highest efficiency of the hospital.

A teaching hospital, such as the new Jefferson Medical College Hospital, will not be content solely with making the best possible

provision for the treatment of injury and disease and for imparting knowledge, it will recognize as one of its most important functions also the increase of knowledge. Although I am approaching the end of the time allotted to this address, I can not pass this subject by without reference, albeit necessarily a hurried one.

For purposes of accurate diagnosis and treatment by modern methods a general hospital must nowadays be supplied with no small equipment for clinical laboratory examinations, and a good pathologic laboratory is now generally recognized as essential to such a hospital even in its routine work. Practical courses in the clinical laboratories are among the most valuable additions of recent years to the medical curriculum.

The problems of disease presented by living patients are the most difficult and complex in the whole range of the physical and natural sciences. Much light can be shed on them by investigations conducted in physiologic, chemical, pathologic, pharmacologic and bacteriologic laboratories, especially by experimentation on animals, but it is increasingly clear that the scientific study of many of these problems can be undertaken with the greatest advantage in well-equipped, special laboratories connected with the hospital clinics and in charge of investigators trained in chemical, physical and biologic methods, with convenient access to the material for study and in close touch with the clinicians. I may cite as good examples of such laboratories those of the university clinic in Munich under the direction of Professor Friedrich Müller.

The familiar analytical and statistical study of cases of disease, based on simple clinical observations, and first extensively and fruitfully applied by the great French clinicians of the early part of the last century, has been of immense service to medicine and will continue to be of service. A good clinical observation has precisely the same scientific value as a fact demonstrated in the laboratory, and, even if more difficult of interpretation, is often the safer guide for the action of the physician.

It is, however, from the special clinical laboratories that we may reasonably hope for a more penetrating insight into the causes and nature of many diseases, an insight which perhaps may arm physicians with a saving power of prevention and treatment of some of the organic diseases of advancing life comparable to the inestimable gifts of bacteriologic laboratories to the prevention and treatment of infectious diseases. We must welcome the establishment of such laboratories and

the new directions which they are giving to medical research. When the purposes of such laboratories are made clear, their foundation and support should make an especially strong appeal to public and private philanthropy.

The medical laboratories of whatever kind and the clinics, while each must cultivate its own special field, are fundamentally one domain, one in their scientific methods and spirit and one in their common purpose to advance medical knowledge and thereby bring healing to the nations.

In this great domain and with this high mission may the Jefferson Medical College and Hospital, with their past of honorable achievement and their future of larger opportunities, grow and prosper, serving skilfully the sick under their care, and blessed with wise counselors, with able and devoted teachers and contributors to medical science and art, with zealous students from far and near, and with loyal graduates—an institution standing in this community and throughout the land as a powerful influence for all that is best in our profession!

THE MEDICAL SCHOOL AS PART OF THE UNIVERSITY[1]

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In our educational systems, as in most of the complex institutions of human origin, the changes that are constantly occurring do not seem to follow a course of continuous symmetrical development. The manner of growth appears to resemble rather that process of exuviation with which we have been made familiar in the life history of the humble crab and his crustacean relatives. That is to say, at certain more or less regular periods our systems become enveloped in a case of customs and traditions of shelly consistency, which, while it serves as a protection against dangers from without, afflicts greviously by and by the growing parts within. In the end the increasing pressure becomes distressing or painful and the only way out of the predicament is to molt the old shell and grow as fast as possible before a new one takes its place. The system of education in medicine has in fact been undergoing a molt for some years past and what I have in mind to-day is to call attention to the fact, perhaps already sufficiently obvious, that the process is not entirely completed. While certain parts of the system are free from the old constricting influences and are at liberty to grow and expand in proportion to the measure of vitality with which they are endowed, other parts are still encased in ancient shell which serves as an obstacle to their proper development.

During the last twenty years especially medical education and the condition of medicine in general in this country have been the subjects of much earnest discussion. Critics within and without the profession have exposed its weakness in the merciless way appropriate to their rôle, and reformers have cried aloud its deficiencies from the house-tops. One naturally inquires what is the cause of all this stir? What has happened to create such dissatisfaction with a system that formerly was accepted without comment? The ills and accidents which afflict mankind are not greater or more numerous than in former times. The

[1] Annual address in Medicine, Yale University. Published in *Science*, July 30, 1909.

pestilence still walks in darkness and destruction wastes at noonday as of old, but not more so. Indeed we flatter ourselves that we are better off than our ancestors in these regards. But we take a different attitude toward them. Our forefathers did what they could to escape these ills and in biblical phrase sought to their physicians with more or less satisfactory results. But what they could not avoid or prevent they accepted submissively as an act of God, a phrase which some one has defined in comprehensive manner as including all those acts which no reasonable man can foresee. In these latter days, on the contrary, there is a widespread feeling that man should be able to apply his intelligence so as to reach a more satisfactory understanding and control of disease and pestilence. The reason for this change of attitude toward nature is to be found, without doubt, in the great increase in our scientific knowledge. Physics, chemistry and biology have added immensely to our comprehension of the processes of nature, living as well as dead, and this acquisition has awakened in us a keen desire to apply all this knowledge practically in saving ourselves as far as may be from sickness and death. If we can find out the secrets of the stars and bend the forces of nature to our use and pleasure, can we not also unravel to some extent those mysteries of life and death which after all are the phenomena of paramount importance to us in this universe in which we find ourselves placed. This same desire to apply scientific knowledge to practical medicine was apparent in Europe early in the nineteenth century. Investigations of the laws controlling inanimate nature had spread rapidly to a similar study of the properties of living matter, although the transition was attended by some convulsive qualms among the timid and superstitious. Foolish and ineffectual attempts were made to discourage the bold pioneers by charges of impiety or by predictions of the necessary futility of all efforts to solve such great mysteries. In medicine, especially, this kind of opposition was very common, and the enlightened members of the profession contended against many unnecessary difficulties in their efforts to introduce the methods and results of science into the practise of medicine. Our own country was very slow in feeling the effect of this movement. We are all aware that medical education and therefore medical practise in this country, speaking in general terms, were until recent years far below the standard maintained in Europe. Conditions among us, in fact, were such that for a time things went from bad to worse. Our curve of

efficiency kept falling, while in other civilized lands it rose more or less parallel with the growth in scientific knowledge. There thus came to us a certain distinct and admitted inferiority in medical matters which has not yet been fully overcome. Many excuses and reasons might be offered for the backwardness of our development in medicine, but the excuse most frequently made was and is that our growing country has need in the outlying districts for an inferior type of physician willing to work hard for little pay, and consequently entitled to receive his degree in medicine at little expense of time or money. A need of this kind undoubtedly existed, but it scarcely justified the creation of the numerous poor schools with which this country was afflicted, and whose ill-prepared graduates practised in the centers of population as well as in the outposts of civilization. One can not entirely suppress the suspicion that motives of personal gain and commercial expediency were largely responsible for the deplorable condition that prevailed in the latter half of the nineteenth century. A few schools possessed of good traditions made an earnest fight for better things under very adverse circumstances, and we must recognize that among the graduates of the poorer schools there were some who became able and even famous practitioners. I venture to believe that this latter result was in no way due to the system, but is to be explained by the fact that the profession of medicine will always draw to itself a considerable number of able and high-minded men, who are bound to make themselves felt upon whatever system their education may be conducted. But the general output of medical graduates was for a time far inferior in quality to that supplied to other nations. What else could be expected from a system which permitted, indeed actively encouraged, men to enter the medical school without any previous education and then qualified them to practise upon the public after a bare ten or twelve months' study of the science and art of medicine? It was much easier at one time to enter the profession of medicine than to become a recognized journeyman in a trade. The conditions indeed became bad enough to call urgently for reform, and this call has grown increasingly imperative down to the present day. In a democratic country like ours a reform in a system of education is naturally a slow process. Under a more centralized form of government it is only necessary to convince the few who have authority and the desired reform may be inaugurated promptly and effectively. But with us it is requisite to arouse the people at large. If an improvement

is called for it can only be established permanently by creating an enlightened public opinion in its favor. It happens therefore in medicine as in politics that the country gets about the kind of service that the majority thinks it wants, and progressive leaders have a very hard time in making that majority change its ideas. Certainly in medicine the effort for reform has been a long and laborious one, but we may feel sure that now the tide of public opinion has turned in favor of a better system. A necessary preliminary step was the development of an appreciation of science in this country. Fortunately our colleges and universities have made splendid progress in this respect. They have created a scientific atmosphere, they have let loose among us a scientific spirit which has entered like a ferment into the medical schools. There, like a ferment, it has caused much commotion and unrest of a healthy and normal kind, the end-result of which will be no doubt the establishment of a system of medical training as good at least as that found in other countries of the same grade of civilization. It may be interesting to inquire how far we have advanced toward this desirable end, and in what direction our present tendencies are taking us. The positive results of the agitation begun during the present generation are important and satisfactory. Our schools, if we take them all into account, are still so heterogeneous that it is scarcely possible to make any general statements that shall be equally applicable to all, but we have an increasing number of strong schools which are setting the pace for the rest, and those that can not keep up will have to drop out of the race altogether. According to reports thirty schools surrendered to this fate during the past five years. The better schools, which we need alone consider in this matter of the status of our development, are organized, almost without exception, as the medical department of a university. Herein lies the secret of their success and the promise of their improvement in the future. In these schools there is firmly established a four years' graded course, of which the first two years are devoted largely to the preparatory medical sciences of anatomy, physiology and pathology, using these terms in their broad sense to include such subjects as histology, physiological chemistry, pharmacology, etc. The most significant fact, however, is that these preparatory sciences are taught by specialists who give their entire time to the work, and whose methods and ideals differ in no essential respect from those followed by teachers of physics, chemistry and

biology. In other words, the instruction in these medical sciences has been raised to the university level, as has been the case now for so many years in the German schools. The change in the character of the instruction in these subjects has brought it about that in many of our colleges and universities they are accepted as appropriate courses for academic degrees, a recognition which I believe will soon become general. For when properly taught a course in anatomy, physiology or pathology gives a liberal education and a mental training which are of value to any man, whatever may be his career in after-life. These subjects deal with the great problems of existence, the riddles of life and death and propagation, and all the properties of that extraordinary substance which we call living matter; they throw light not only on the special questions that interest the physician, but they furnish also valuable material for the practical use of the sociologist, the political scientist, the philanthropist and the statesman. Moreover, they bring us close to the highest and most difficult subject that the human mind is called upon to contemplate, that is to say, the relationship between ourselves and the material universe, the ever-fascinating and mysterious interdependence of mind and matter. Much has been said upon the subject of the cultural value of liberal studies as opposed to so-called professional or technical studies, but in all discussions of this kind there is a tendency toward a certain arbitrary assumption that courses of studies must fall wholly under one or the other of these rubrics, whereas common experience teaches us that merely putting a label upon a thing is no guaranty that the contents are thereby properly described. The preparatory training for life should be liberal and humanizing, but it is quite possible that many different lines of study may lend themselves with equal success to the development of these qualities, and it will be admitted perhaps by every one that the courses of study in college, in addition to having a broadening influence upon the student, should also inculcate in him some specific kind of mental training which will fit him better to take a high rank in whatever career he may happen to select.

The term technical, as applied to courses of instruction, has acquired an unfortunate connotation which implies that they are lacking in value from the standpoint of general training. As a matter of fact, many of the graduate courses given in our universities are quite as technical as those given in the preparatory sciences in the medical school, and

for one as for the other it is short-sighted to assume that they are devoid of a general educational value. I prefer much the definition of the term technical which has been given by Professor Karl Pearson. He makes a distinction between technical and professional instruction, or, to use his precise terms, between technical education and professional instruction. Under the latter term he includes training in the art of a specific profession—that kind of training which the apprentice gets from his master in the specialized methods and handicraft peculiar to the vocation—the kind of training which, in the case of the physician, is obtained in the wards and clinics in contact with patients. By technical education, on the other hand, he means that training in the underlying subjects of a profession which makes for the development and strengthening of the mental faculties. The technical education of the physician in this sense lies in the physical and natural sciences, including under the latter term the whole range of the biological sciences. Whether any given course in this category meets Pearson's definition of technical education is determined by asking whether it "provides mental training for the man who has no intention of professional pursuits." Judged by this standard, we may understand that it is the method in which a science is taught as much as its contents which determines whether or not it has value as an intellectual preparation for life. I have no doubt that various subjects, scientific or otherwise, are taught at times within the walls of the universities in such a way that they miss the larger end and confer only the restricted benefit of a special knowledge which is truly professional for that subject. There can be, however, no hesitation in claiming that the subjects of anatomy, physiology and pathology as they are taught or should be taught in our best medical schools are adapted to give a training to the mind as broadening and as generally beneficial as courses in physics, chemistry, biology or indeed as any of our university courses which deal with special departments of human knowledge. So far as graduate instruction is concerned this contention has long been admitted in this country, and the subjects we are considering are listed upon the programs of study in both the philosophical and the medical faculties. In later years many colleges have gone a step farther and have accepted these courses as part of a general scientific training for those students who are looking forward to a career in medicine. It is perhaps only a matter of a little time before they will be admitted to the same standing in all respects as the other sciences,

that is to say they will be considered not only as subjects of special medical interest, but as conveying knowledge of the widest human interest and importance. So far as the subjects themselves are concerned they enjoy their widest opportunity and best environment when the medical school forms an integral part of the university, not only in organization, but in location as well. If it so happens that geographically the medical school is separated from the rest of the university it is not a matter of vital importance, so far as I can see, in which set of buildings these subjects are taught, provided only the teachers are of the right sort. This opinion, I am glad to say, is merely by way of confirmation of the practise that is actually coming to be established among us. When these subjects are segregated with the clinical branches something, no doubt, of the university atmosphere is lacking; when they are separated from the clinical side there is a corresponding loss of medical atmosphere. Which is the more serious loss, or whether there is any material difference in the final result, it is difficult to say. The medical student probably values more highly the medical surroundings. They give significance to the things that he is learning and in various informal ways they furnish him with opportunities to acquire the points of view and the methods of practical medicine. On the other hand, they have the disadvantage of distracting and diverting some students from a thorough study of the preparatory sciences. I have had frequent occasion to observe this effect. Some of our medical students chafe under this prolonged preparation, forgetting the fact that it is an opportunity which may never come to them again, and forgetting also that it gives them the badge, the impress that will differentiate them from the mere empiric, when the time comes for them to compete with their fellow practitioners. To the teachers, on the contrary, particularly if they belong to the productive type, the university atmosphere is perhaps more stimulating. The methods and ideals of these teachers are more closely related to those of the university professors than to those of their clinical colleagues. For while research is valued as much perhaps in the medical department as in the philosophical department, there is the difference that in medical circles the reward of immediate appreciation goes chiefly to those investigations that promise to have a direct practical application. The medical atmosphere encourages research by the sharp stimulus of an abundant reward for practical results. The university spirit or the academic spirit, on the other hand, takes the

wider and wiser view that looks beyond the immediately useful to the large results that may be expected from a growth of knowledge in general. This serener atmosphere forms a grateful environment for research, and in the long run no doubt it produces the larger harvest of useful knowledge. Investigation after all is always a voluntary offering. There is no way of compelling it or of estimating its value in terms of time or quantity, and men who investigate do not like to be put under the pressure of demonstrating that the work they do is of immediate importance to mankind. They prefer to study those problems which for one reason or another have aroused their interest. Considering the complexity of nature, especially the living side of nature, and remembering how difficult, even dangerous, it is to apply knowledge that is incomplete, the rest of mankind would do well to encourage in every way the little band of investigators whose chief ambition and pleasure in life is simply to add to our store of knowledge. As a matter of fact mankind generally does not place a very high estimate on the work of these disinterested individuals whose labors contribute to the common good rather than to personal gain, although history teaches us in an infinite number of ways that on the work of such men depends in large measure the possibility of progress. Perhaps the explanation lies in the fact that the good these men do comes after them, it benefits posterity rather than the present generation, and we are inclined to let posterity do the appreciating as well as the benefiting. But this is a line of thought aside from our present purpose. The conclusion that I wish to emphasize is simply that all the agitation that has been going on in medical circles during the past two decades has resulted finally in the establishment of two reforms in medical education. First, the preliminary training for entrance upon the medical career has been greatly increased. Starting with practically nothing at all, it was raised first to a common-school education, then to a high-school education and finally, in the university schools, to a college preparation, partial or complete. Second, in the medical course itself the work of the first two years has been so arranged that it continues the traditions and methods of the university in the study of the so-called underlying medical sciences. It will be observed that these two important results have to do with the preparation for practical medical work. On the old system two years were given to acquiring a sufficient knowledge of the art of medicine. As scientific knowledge increased and penetrated

into medicine the period of instruction was prolonged to four years, or, taking into account all of the necessary preparation, to six or eight years, but all of this additional time was devoted substantially to preliminary or preparatory training. This is a significant fact. All of the truly art side of medicine or of any other profession may be acquired on the apprenticeship system, without any previous preparation other than is implied in a basis of general intelligence. It is the scientific side of medicine which calls for all of this extensive preliminary training. Without it one might still in a two years' course make a capable practitioner, to use a distinction made long ago by Magendie, but not a scientific physician. The difference between an able practitioner and a scientifically trained physician is not so striking that it can be appreciated at once by the public at large. The difference is there, however, and eventually it means everything to the advancement of medicine to recognize this difference and to increase it by every means at our command, whatever cost of time and money it may entail. Excellence is generally the thing that costs. If by the expenditure of more money we can add a knot or two to the speed of our steamships we know that it pays us to do so, and if by longer and more expensive training the efficiency of the physician may be increased a little, the difference is worth the cost, for it also will add much to the happiness and prosperity of the whole community.

The content of the curriculum of our first two years, and the character of the instruction given during that period, may be modified more or less from time to time. It may be expanded or more probably it may be simplified, but it seems to me that our system of medical instruction in this country is committed definitely to the general principle that these medical sciences shall be taught as the other sciences in the university are taught, by specialists who give their entire time to the work and who are active in research as well as in instruction. The force of successful example will compel all schools to follow this type. But, we may ask, is there no change that is desirable in the system of instruction in the clinical branches? This is a question which ought to be discussed by clinicians as by those who know whereof they speak. But it is a general truth, perhaps, that reforms in teaching do not usually originate from those occupying the positions in which changes are called for. Feelings of personal interest or loyalty to traditions prevent them from seeing clearly the defects that may be obvious to others. It comes

about, therefore, that the initial impulse to reform is often forced upon us by criticism from without. In regard to the teaching of the clinical subjects in our medical schools three general changes have been suggested at one time or another which are likely to come up for serious consideration in the immediate future. First, shall the time devoted to these subjects under the auspices of the medical school be lengthened? At present the usual plan is to give two years to this side, and the definite suggestion made is that a third, exclusively hospital year, shall be added. I shall not stop to discuss this question. Our graduates themselves realize the value of this additional experience and in increasing numbers every year they are seeking a term of service in the hospitals before entering upon private practise. It seems to me most probable that we shall find it advantageous to follow in this respect the example set for us by the older countries, that is to add a year of hospital service as an obligatory part of the requirements for the degree in medicine or for the license to practise medicine. As we all know, this change has been strongly recommended by the council on education of the American Medical Association. Second, there is much complaint from many sources, particularly from the teachers of the medical sciences, that the professors of the clinical subjects do not make adequate use of the results and methods of science in their instruction. What is the use of giving the student a scientific training if the man who instructs him in diagnosis and treatment neglects to show wherein this knowledge is applicable? This is largely a matter of comparison. We know that in foreign countries the clinical teacher is usually well prepared to use the results of science. In our own country, outside some anatomy, normal and pathological, this statement can not be made. Our best clinicians heretofore have been lacking in acquaintance with the facts and methods of the underlying experimental sciences. This, however, is a defect which time no doubt will remedy. The newer appointments to these chairs will be made from a group of men who have enjoyed the benefits of a better scientific preparation. It would, however, be a real advance if we should adopt what seems to be a practise in other countries, namely, to require those who expect to take positions upon the medical or surgical staffs to serve a preliminary year or two in a scientific laboratory, engaged upon research not too immediately practical in character. The suggestion made by Dr. Bevan that the positions upon the clinical staff might be filled by men who had served as instructors in anatomy,

physiology or pathology is most excellent. If this procedure became customary, if the professor of medicine, for example, selected his assistants from the teaching staff of the departments of physiology, physiological chemistry and pathology, we should have an arrangement which, on the one hand, would supply the clinical departments with well-trained men, capable of undertaking independent investigations, and, on the other hand, would probably direct toward the laboratory subjects an abundant supply of young medical graduates, whereas under present conditions it is frequently necessary to go outside medicine in filling such positions. Third, What shall be the character of the duties and qualifications expected from those who have the chief direction of the work in the clinical departments? It is an interesting and somewhat surprising fact that in this part of our system of medical education no change of importance has been made in the methods of teaching during the last few decades. So far as the student himself is concerned no fundamental change in opportunities is required. Clinical instruction from the students' standpoint always had the great merit that it employs what we may call the laboratory method, as opposed to the method of learning from books. The student is brought face to face with experiments made by nature and he is given an opportunity to learn from personal experience rather than from the experience of others. In our modern schools his opportunities of this kind have been greatly increased and to this extent his instruction has been improved in his clinical years along the same line as in his preparatory years. But has there been a development in the methods of teaching in these clinical years corresponding to that which has taken place in the laboratory subjects? What we find is that the backbone of the instruction in the clinical branches consists now, as formerly, of exercises in the clinics and operating rooms of the hospital and the dispensary, and these exercises are conducted by practitioners of medicine who devote a little time to their duties as teachers, but give most of their time and energy to their private interests. As long as our medical schools were private corporations founded partly for the public good, but partly also for the personal advancement of the members of the corporation, this division of time was natural and permissible. But our best schools are no longer private enterprises; they constitute a part of a university whose functions are solely to advance the public good and not in any sense to exploit private interests. As has been well said by one who

speaks with great authority, the university discharges its direct duties to the public in two general ways, by teaching and by investigating; by providing systematic instruction in all forms of that knowledge which has been accumulating from the beginning of our race, and by promoting all good methods for increasing knowledge. These duties are performed through her teachers. She therefore selects her professors for their ability to teach and to investigate, and to insure that these functions are performed in the best possible way they are required to devote themselves entirely to her service. In this respect, as we know, the professors in the clinical branches, and possibly also the professors in some of the other professional schools, are on a different plane from the university professor proper. It seems to me a perfectly proper question to ask whether this distinction is a necessary and advantageous one. Does it constitute an inherent characteristic of professional instruction? This is a somewhat delicate and complex question which should be discussed not simply from the standpoint of the ideal, but also with reference to what is really feasible under conditions as they exist. Time does not permit such a discussion and I must limit myself to a brief statement of what seem to me to be the tendencies now developing. One curious, if not important, phase I may note in passing, namely the practise that seems to be growing of paying the clinical professor the full salary given to the other professors in the university. The professor in the clinical subjects is designated as a professor in the university, and although he is permitted to engage in a lucrative private business he is given a salary as large as that paid to the usual professor who devotes his entire time to his university duties. There is a manifest inequity in this practise, and it produces a distinct feeling of discontent among the teachers. It would seem to me that the university ought not to submit to this condition, unless it is actually forced to do so to obtain the men that it wants. As a matter of fact, the indirect benefits attached to these positions in a good university school are so great that I believe there would never be difficulty in obtaining the best men to fill them whether they carried salaries or not. But if a salary is attached it should certainly not be so large, under present conditions, as that paid to other university professors, otherwise the university deliberately places a premium on the teaching done by the clinical instructors which tends to discredit the work of the other teachers. But this is a more or less incidental matter. The really

important standpoint from which to view the subject is what are the means by which the university, through its medical department, can discharge most efficiently its obligations to the community. It wants to send out practitioners of medicine qualified in the best possible way to treat the sick, it wants to do its part in throwing additional light upon the causes and treatment of disease. Now the first of these functions is not so very difficult of performance. Under conditions as they are teachers of medicine and surgery can be obtained who will give to students the best methods of diagnosis and treatment, and so far as the limited time permits will send them out into the world prepared to develop into competent practitioners of medicine. There can be no doubt, however, that this function would be performed more satisfactorily from the standpoint of the school if an arrangement could be made whereby the professors gave more time to the work of instruction. The provisions made for the advancement of knowledge by investigation are not so satisfactory as they should be. Whatever may be the position of a proprietary school in this particular, the university school surely can not be satisfied with playing the part of a mere reflector of knowledge. The spirit of investigation is wide-spread in medicine at the present day. We have the highest kinds of hope that the methods of science may be applied with success to the study of diseases of all kinds. There has been an extraordinary increase in our knowledge of infectious diseases, and resulting therefrom a really wonderful improvement in our control of the conditions threatening public and private health. All this we owe directly to the use of the laboratory method of investigation. A similar victory may be gained over the numerous constitutional and nutritional diseases whose causes are at present hidden in the secrets of the body metabolism, but to accomplish this desirable end, or at least to accelerate its accomplishment, we must organize more satisfactorily our means of investigation. Shall we limit our investigations to the laboratories of the medical sciences and to special institutes, or shall we extend them into the clinical branches? It is almost useless to put such a question. Investigation by experimental methods has spread into the clinical departments, and a great increase in the development of this phase of research activity may be regarded as inevitable. The point that has been raised and which I should like to emphasize is that our present system is not well adapted to promote this kind of work. Our custom is to appoint as heads of these departments men who are

engaged in the practise of medicine, and it is perfectly evident that if these men give themselves unreservedly to the demands of practise their efficiency as teachers and investigators will be seriously impaired, indeed, in the latter particular, will probably be destroyed altogether. To attain the combination of those qualities which are most desirable from the view-point of the university one of two changes should be made. Either there should be a definite limitation placed on the time given to outside practise, so that opportunity of a known extent may remain for teaching and research, or these positions should be placed squarely on a university basis, the practise of the incumbents being limited to the hospital and dispensary and the laboratories attached to them. The two propositions bear to each other somewhat the relation of a half loaf to a whole loaf. Neither of these principles is in force to-day, so far as I know, in any of our better schools. Investigations that bear directly on the problems of practical medicine are carried on in the laboratories of the medical sciences, in the special institutes, and by the younger men in the clinical departments who are preparing themselves for higher positions. We possess also a certain small number of professors of medicine and surgery who, in spite of abundant opportunities offered to enlarge their incomes, are so deeply interested in the work of investigation that they voluntarily limit their outside practise and devote a considerable portion of their time and energy to genuine research. These are noble spirits, for they make a real sacrifice for the sake of a worthy principle. Medicine owes much to them not only for results actually obtained, but also for their example and influence which permeate the whole department with which they are connected, and affect favorably to some extent every student brought into contact with them. But the number of such men is very small, for I would not add to this honor list those whose names appear sometimes in our literature as contributors, but who are in reality patrons of research rather than actual workers. The position of our clinical professors in relation to their duties toward the school, on the one hand, and their opportunities for increasing their private practise, on the other, is so similar to that which formerly existed in the departments of the medical sciences that one naturally assumes a similar outcome. The practitioner was displaced from the chairs of anatomy, physiology and pathology, because the scientific knowledge and laboratory technique had become so specialized that it was impossible for the man in practise

to do the professorial work with honor and success. The principle of competition between the schools soon determined which kind of professor was most needed. In the same way precisely science and laboratory technique and the spirit of investigation are pushing hard into the clinical branches. The professor of medicine who gives himself to outside practise, and at the same time attempts to keep up with the scientific development of his subject and to make and direct the investigations which his position in a good school demands is putting himself under a great strain at present, and the indications are that soon this strain will become too great. Specialists will be demanded for the heads of our practical branches as they are now for our theoretical branches. It seems quite possible that here again the principle of competition will be the decisive factor. The university school which shall first establish departments on this basis may, and in my opinion will, secure both reputation and students as compared with schools organized on the present system. Whether a professor of medicine, surgery, obstetrics, etc., whose practise upon patients is limited to the hospital and dispensary will be as well qualified as the man with an extensive outside practise to teach his students medical art as well as medical science, and to attain the proper influence among his brother physicians, are questions that have been somewhat discussed, but the only way to find out the correct answers is to try the experiment. All the theoretical reasons favor such a change. The practise of the hospital is much more rigorous than private practise from the standpoint of the acquisition of the methods of diagnosis and treatment. I fancy that any physician will admit that experience and real knowledge accumulate at a rapid rate in the hospital as compared with the results of the looser discipline of outside practise. A man whose diagnoses are based upon the most complete examinations possible and whose errors are continually subject to the salutary correctives of autopsy and pathological demonstration is likely to make a very exact and practical teacher. As regards the matter of the relation of these men to the medical public there can be no room for a difference of opinion. It is they who would have the golden opportunity to acquire precise knowledge, to keep thoroughly abreast of the latest and best in the medical world. It is they who in medical societies and medical journals would be best qualified to speak with full knowledge, and in professional circles knowledge gives authority, whatever may be the case with the

public at large. A practical difficulty in making such a change in the character of the appointments to the clinical chairs is the doubt whether properly prepared men would be willing to surrender the rewards and popular appreciation that are attached to the career of a successful physician. This is again the kind of question that discussion does not throw much light upon. When we meet with difficulties of this kind in laboratory work we put the matter to the test of experiment and thereby settle the dispute. Our country is in a peculiarly favorable position to make such an experiment. Our system of medical education has heretofore simply developed along lines laid down by the experience of foreign countries; perhaps in the direction suggested above we may have an opportunity to take the lead instead of trailing along in the rear. I have had occasions to talk with a number of young clinicians on this topic and I have arrived at the conviction that many of them would eagerly accept an offer which, while assuring them a modest but sufficient competence, would also open to them a career so promising in influence, reputation and possibilities for doing the highest good to mankind.

LIBERTY IN MEDICAL EDUCATION[1]

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A quarter of a century ago the medical schools of this country gave an annual course of lectures which was attended by all students and was repeated each year. For this privilege students paid a single fee, for which they heard much, saw little, and did nothing. There were no requirements for admission and very few for graduation. At the end of the session the trustee-members of the faculty divided the profits among themselves. Since that time, however, great strides have been made in the direction of improvement, stimulated mainly by other educational movements in the country. The quality of the professor has been improved, a graded course of instruction has been introduced, and requirements for admission have been established. These improvements have been supported chiefly by the educated people, on the one hand, and by the medical profession, on the other, by causing state laws to be introduced regulating the practise of medicine. Schools of medicine have thus grown from one course of lectures, extending over five months, to four graded courses of nine months each. The requirements for admission have been increased from *nil* to a liberal education as expressed by a college degree. The quality of the professor has also kept pace with the increased requirements of the medical school.

There are at present in the United States forty-eight medical colleges having courses extending over three years, and seventy colleges having courses extending over four years. Of the latter group, fourteen have sessions of eight months each and eight have sessions of nine months.[2] This group of eight schools has in general increased the requirements for admission to a high-school education, while one of them demands a college education with a college degree. Two of them have announced that in the near future the requirements for admission shall be increased beyond the present standard. On account of the lead thus

[1] Published in *The Philadelphia Medical Journal*, April 1, 1899.

[2] Report of the Commission of Education, 1896–'97, Vol. 2, p. 1792.

taken by these institutions, as well as for their general good standing, I shall term them medical schools of the first order.

In order to raise the standard of the medical schools of twenty-five years ago to that of the schools of the first order as they exist at present, it has been necessary to pass through the stages of graded courses, for in so doing not only could the value of graded and progressive courses be demonstrated to all who took them, but at the same time unworthy students could be eliminated. Experience teaches that the student who has been well trained in the fundamental departments of medicine demands a more careful training in subsequent studies; accordingly it follows that if we wish to attain to higher standards in the practical branches the teachers in the fundamental departments especially must be first improved. An effort in this direction is what we are witnessing at present all over the country. The institutions are demanding better courses in anatomy, physiology and pathology, while the students, *propter hoc,* are demanding better medicine and surgery. If I have calculated correctly the forces at work the outcome of the movement will be that in less than another quarter of a century the standard of the schools which remain will be as high as that of the schools of the first order is at present. Such a result, of course, absolutely depends upon the schools of the first order retaining the lead, and on their gaining in addition stronger support from improved state examinations.

The immediate effect of the introduction of the graded course of three years, in 1880, was a marked falling off of the total number of medical students, and this decrease continued until 1887.[8] Since then the number of students has gradually increased until at the present time there are more than twice as many students as there were ten years ago. Graduates of recent years know only too well the difficulties in gaining a livelihood, and our present students, with greatly increased opposition from state laws, the multiplication of dispensaries, and the distribution of trained nurses, have also a very poor outlook. The improvement in the quality of the student and of his education will not necessarily guarantee a practise when there are already too many physicians.

The schools of the first order have before them a responsibility far greater than increasing the number of their students and of graduates. In order to keep in the lead they must at once improve the quality of their teaching-force and also give better facilities to select students. At

[8] Report of the Commission of Education, 1896–'97, Vol. 2, p. 1190.

the University of Michigan and at the Johns Hopkins University the authorities are in no way hampered in the selection of their professors, and nearly all the latter are chosen from distant universities. The other medical schools of the first order are rapidly adopting the same method. This is a most hopeful sign, for nothing is more detrimental to educational institutions than the "inbreeding" of professors. To increase the length of the medical course beyond four years does not seem to me to be advisable. The requirements for admission to the Johns Hopkins Medical School are sufficiently high,[4] and the other schools of the first order promise to approach this requirement.

In the old medical course of one session, the student at best gained some idea of medical lore, and, in case he was deficient in this, he took the course again, thus making a two years' course of it. When the three-year graded course was introduced the second year was the first year taken over again, with a special third-year course added. In this way the student heard each course of lectures twice in order to make him retain the facts. But from examination it was found that the student remembered but little of what he had heard, and a new force was introduced to aid him in the memorizing process. Young instructors or individuals not usually connected with the institution extracted the essence of the course of lectures and drilled this into the classes. Thus arose the quiz method of instruction, so common in many medical schools. This helped the student to remember a sufficient amount to pass the examination, and all appeared satisfactory, for no one asked whether or not the student had actually gained knowledge and skill enough to practise medicine and surgery. Even to-day it is the recitation upon the lectures, laboratory work, or an assigned subject from a text-book that is employed as a test of a man's capacity. In all cases it is "learn the lesson we have set for you, recite well, then pass the examination, and after you have satisfied each instructor in this way, you are a Doctor of Medicine." In my opinion no method of training could be worse for a good student, while it puts a premium upon the mediocre candidate.

[4] A degree in arts or science from an approved college, at least a year's laboratory training in physics, chemistry and biology, and a reading knowledge of French and German. After June, 1901, candidates for admission to Harvard Medical School must present a degree in arts, literature, philosophy, science or medicine, etc.—Announcement of the Medical School of Harvard University, 1898–'99, p. 12.

If we ask the question—how may we make it possible that the individual may assert himself, and how can we give the student a chance to test the use of the knowledge he may possess?—we need not seek far for the reply. We have only to inquire into the methods in vogue in the leading medical schools of Europe, which are in many respects identical with those of the graduate schools of our own universities. European medical schools and American graduate schools afford facilities in a great variety of subjects for those who may profit by them. When the student has pursued enough courses (no two students necessarily having followed exactly the same course) to enable him to apply for a degree, he is examined, and in case he passes, the degree is granted him. Adapting this more liberal method to our own medical schools a plan may be formulated as follows:

1. Entrance examination. Followed by at least two years' study of the fundamental branches.

2. Intermediate examination. Followed by at least two years' study of the practical branches.

3. Final examination. The subject of examinations will be referred to further on in the course of my remarks.

Throughout the course thus outlined, the greatest latitude possible should be offered the student in the arrangement of his studies selected from (1) a required list, as well as from (2) an extensive group of electives, as recently advocated by Bowditch.[5]

We all know that students are very unequal in ability, as well as in capacity for work, and why should they all pursue the same course of study? It is certainly very injurious for students to repeat courses with which they are familiar, feeling at the time that they do not grow from day to day. Furthermore, it is not beneficial to the true student to study with a whip over him, and we know only too well that this weapon is more often used by a poor instructor upon a good student than

[5] Bowditch, *Boston Medical and Surgical Journal*, December 29, 1898. At present there is an elective system at Harvard and at the University of Pennsylvania, representing about 2 per cent. of the entire medical course. President Harper has just introduced an elective system into Rush Medical College, representing 17 per cent. of the entire course. There are elective courses at the University of Michigan, Columbia and Johns Hopkins, but they do not give credit to the student further than the increased knowledge he may gain in taking them. Students already overworked are not likely to take electives without prolonging their course of study, and there is so much disgrace accompanying the prolongation of the medical course under the present arrangements that this alone debars students from wilfully doing it.

by a good instructor upon a poor student. If we had a liberal elective system the student would know why he takes a course, and under this condition should profit much more by it. To profit most the student must gain a perspective of his medical course. In my association with German medical students I have witnessed frequently the value of this point, emphasized centuries ago by Quintilian. While battling to establish themselves in an elective course of study a certain number fail and quietly withdraw from medicine; the average students continue along the trodden path, while the strong students become much more powerful.

Do we, with our obligatory methods, accomplish as much? I think not. We cast out the poor students and disgrace them, the mediocre continue along the trodden path, but the best are retarded. We do wrong when we disgrace the weak and it is our duty to develop the strong. It is poor logic and begging the question to assert that the German student develops better under the banner of liberty than the American would. It is not difficult to obtain overwhelming authority in favor of liberty in higher education; it is only degrading to our profession in America to assert that our students are not worthy of it. As long as this continues, medical education in America, in spite of the advance it has made during the last twenty-five years, will remain at its present low level in the eyes of the educators of the world.

> Only a few years ago all students who graduated at Harvard College passed through one uniform curriculum. Every man studied the same subjects in the same proportions, without regard to his natural bent or preference. The individual student had no choice of either subjects or teachers. This system is still the prevailing system among American colleges, and finds vigorous defenders. It has the merit of simplicity. So had the school methods of our grandfathers —one primer, one catechism, one rod for all children. On the whole, a single common course of studies, tolerably well selected to meet the average needs, seems to most Americans a very proper and natural thing, even for grown men.*

What is written above has in it the spirit of iconoclasm, and it remains to be shown, and I think it can be shown, that it is possible, in fact necessary, to bring about a change in the curriculum, even in the schools of the first order, to relieve their congested, illogical, and often absurd medical programs.

The following table has been compiled from the announcements of six of the leading medical schools and I give it with considerable reserva-

*Eliot, Inaugural Address as President of Harvard College, October, 1869.

tion. Any one trying to confirm it will appreciate the difficulty in determining the duration of the various courses in them.

TABLE SHOWING THE NUMBER OF HOURS' WORK GIVEN IN THE VARIOUS DEPARTMENTS OF SIX OF THE LEADING MEDICAL SCHOOLS

	A	B	C	D	E	F
Anatomy and histology	500	500	950	890	695	825
Physiology	250	210	300	150	120	160
Physiol. chemistry and pharmacology	275	105	300	250	465	530
Bacteriology and pathology	300	185	200	570	330	560
Other subjects	150	60	240		255	595
Medicine	625	420	460	515	480	320
Surgery	470	390	385	570	670	660
Gynecology	60	180	160	235	260	380
Obstetrics	200	180	220	280		
Dermatology	30	120	40	100	100	95
Pediatrics	15	90	40	80	90	
Nervous diseases	30	100		120		325
Genito-urinary diseases	15	30	65	120	110	480
Laryngology	15	120	40	100	120	
Ophthalmology	100	300	40	100	105	
Other subjects	90	330	75	80	90	90
Total	3,125	3,320	3,515	4,130	3,890	5,020

In glancing over the lines it is seen that the time devoted to any of the important subjects varies fully 100 per cent. in different schools. In some of the specialties it varies nearly 1,000 per cent. These facts in themselves are overwhelming evidence in favor of elective courses. If the correct quantity and order of the subjects are known, as is so frequently asserted, why this great fluctuation in hours? If a student of his own accord takes 325 hours of nervous disease at school F, that is his own affair; but why should all students take 325 hours? At school A, on the other hand, if he desires to take but 30 hours, it is again his own affair, but why should all of them take so little? A similar argument can be applied to every course. Were the elective system in vogue a student might arrange the studies of school A like those of any of the other schools given in the table, or he might have any intermediate gradation. But how can this be done? We know that in all of the leading schools the year is divided either into two semesters, or into three terms. Let us consider only the institutions with two semesters, and what applies to them may apply equally well to the others. Several fundamental principles will have to be introduced.

1. The work in each department must be graded.
2. No course may extend over one semester.

3. The courses must be concentrated. Every course should be given at least three hours a week. Individual course-records must be kept, as is the case in all colleges.

For the sake of brevity I will designate a course of three hours a week for one semester a unit, for half that time a half unit; three half-days' laboratory course for one semester as two units, for half that time as one unit. Within this time all necessary medical courses can be given. The main clinical courses may be longer, but may be cut into blocks of a semester each, and this makes it easy to bring them into the scheme.

The courses in a department being graded, they will have to be arranged in such a manner that students knowing nothing about the work of the department may be given introductory courses in it during each semester. After the introductory courses have been taken they may take then the more advanced work of the department. The outcome of it all will be that each student will work at a speed to suit himself, conforming only to the rules and regulations of the department, and being controlled in addition by the examination system of the university, as follows. He may not enter the school as a candidate for the degree of M.D. without having passed the entrance examination. He may not take any of the practical branches without having passed without condition the intermediate examination, the time between the entrance examination and the intermediate examination to be fixed at a minimum of four semesters or their equivalent. In case he is conditioned in any course he may be examined one semester later. The same rules may apply to the time between the intermediate and the final examinations.

I have used above as time unit the semester or its equivalent. It is noticed in the hours given in the table that the whole medical course at medical school A is 3,000 hours; at F, 5,000 hours. A total of 3,000 hours, or 750 per year, is full work in the undergraduate science course of our leading colleges, and may be considered the standard for a medical course. With three hours a week for one semester as one unit, and three half-days' laboratory work one semester as two units, a student taking six units per semester would be doing full work as rated by college standards. Twelve units would represent a year's work, and twenty-four units two years' work, or the minimum requirements for persons presenting themselves for the intermediate examination. In a more detailed form the work of the best schools can be recast with the above-described unit as basis in some such manner as the following:

TABLE SHOWING THE MEDICAL CURRICULUM RECAST WITH THE UNIT AS BASIS AND OBLIGATORY AND ELECTIVE COURSES

ENTRANCE EXAMINATION

	Obligatory	Elective
Anatomy	6 units	15
Physiology	2 "	4
Physiological Chemistry and Pharmacology	3 "	6
Pathology and Bacteriology	4 "	10
Hygiene and Bacteriology		10
Elective	9 or more	
	24 = two years' work.	

INTERMEDIATE EXAMINATION (ANATOMY, PHYSIOLOGY, PHARMACOLOGY AND PATHOLOGY)

	Obligatory	Elective
Medicine	6 units	15
Surgery	5 "	15
Obstetrics	3 "	5
Gynecology		5
Dermatology		4
Pediatrics		4
Nervous Diseases		5
Genito-Urinary Diseases		4
Laryngology		4
Ophthalmology		5
Medical Jurisprudence		2
Psychiatry		4
Elective	10 or more	
	24 = two years' work.	

FINAL EXAMINATION (MEDICINE, SURGERY, OBSTETRICS, AND ONE ELECTIVE)

In the above table I have arranged the units in two columns, reducing the obligatory courses to their minimum without excluding any of the seven branches. Further cutting down might be an improvement, but I will not raise that question at present. As it stands in the table 60 per cent. of the entire four years is obligatory and the remaining 40 per cent. of the work is to be selected from a large group of elective courses. As they stand in the second column it would require an average student eight or ten years to take them all, and the two columns together represent work which our best schools can easily give at the present time. Much of our whole trouble in teaching is that we are trying to put ten years' work into four.

In case a school measured the time of a student by the number of units he had taken, it might be well to credit him only with six units

per semester in order to discourage overwork. It would be his privilege to do as much additional work as he chooses, but in case he did less than six units per semester he would be credited for the amount he had really taken. The course-records might be controlled by practical tests at the end of a laboratory course or by a brief written examination at the end of a lecture course, it being distinctly understood, however, that these examinations are only to give credit for the course. It might happen that weak students, and often strong students, would take more than twenty-four units before applying for the intermediate examination.

The order in taking the work of the first half of the medical course should not be controlled any more than the rules of any department control them. It might be well for the course in pathological histology to be preceded by histology and microscopic anatomy, but more than this is hardly necessary. If a student desired to take the pathological histology without having had normal histology and the instructor did not object, the student would have to take the consequences. I, myself, did this as a student in Heidelberg and to this day have not regretted it.

After the intermediate examination the student would take the necessary courses preparatory to actual medical and surgical work, and for this purpose there is always an abundance of instructors on hand. The group question would soon disappear, for a student might take sufficient elective courses to save time in reaching his goal, *i. e.*, doing practical work. Each student might try a different combination while working out his own salvation and developing his individuality. The weak student would either drop out or go slower, the average would follow the trodden path, the good one would develop himself. A congested course would soon be duplicated, the arrangement of the program would be extremely simple, and courses of no value would soon die a natural death. Demand and supply would become the important questions of each institution and the "trust" method of supporting either a poor student or a poor instructor would soon disappear.

The great complaint of the good student is coercion. Reared in a free atmosphere, accustomed to great liberty during his college years, he enters the medical school with intellectual slavery staring him in the face. The faculty trust is so powerful that if the student asserts his citizenship and remains away from a stupid course or one useless to himself he may be deprived of his degree. Long after he graduates he awakens to see that it is all a sham, and this fact adds another dis-

grace to our medical schools. Let us boldly define the work which is absolutely necessary for each student to do, give an abundance of electives from which he must select a certain amount and then have a rational system of examination.

The bugbear of examination is so great that in my opinion it would be well to separate it from the course of instruction entirely. Many examinations are such an utter farce, so bad and so detrimental, that both physicians and many faculties have lost faith in them entirely. No greater argument need be given than the fact that the physicians of many states will not permit the members of a teaching faculty to serve on the state examining board, while in some of the medical schools it is required that the student write his examination over a secret number in order that the reader of the paper does not know who has written it. Think of it! Then to bring this evil force into the lecture hall and the laboratory! But some compromise is here necessary, for how shall we determine whether or not the student has really taken the course? In Germany simple payment of a fee for a course and a perfunctory signature of the instructor give the student credit for the course. In Austria the instructor must sign the student's book, to which is attached his photograph with a seal through it at the beginning and again at the end of the course. If we had some method a little more rigid than that in Austria it would suffice, for I think that we should "do away with examinations as much as possible. They produce mediocrity."[1]

The intermediate and final examinations should be true examinations to test a student's knowledge. At least two weeks should be given over to the examination in anatomy, during which time the student should be asked to make dissections, histological preparations and the like. The examinations should not be primarily directed toward finding out what the student *knows;* rather toward learning what he can *do* with the knowledge he possesses. They should always be public in order to protect both the student and the examiner. The great length of time given over to the examination should remove most of the embarrassment of the student, which accompanies the briefer and crushing Ph.D. examination. In addition to the examination the credentials of the student should always be taken into consideration, for it is through them that we learn what the student has actually done, as well as much concerning the general character of the man. With a liberal system of electives no two sets of credentials would be the same.

[1] Paulsen, Rein's Encyklop. Handbuch d. Pädagogik.

The value of liberty in education has been pointed out again and again from the student's standpoint,[8] but the benefit it renders an institution should not be forgotten. Liberty to the student should not mean license to him, but rather liberty also to the instructor. This question stirs our medical schools to their very foundation. At present our medical institutions are properly called schools and none of them can claim true relationship to the university. A medical department of a university must consist of a group of independent departments, each a complete organization in itself, existing primarily as a conservator of the branch it represents. Teaching beginners may become its main work, but should never be its chief ideal. These departments must be related to the university as a whole, as is the department of chemistry or of history, the former being bound together, however, through the medical faculty as the latter are through the philosophical. At present this ideal is reached by a very few departments scattered throughout the country. The rest are better likened to the departments of chemistry and history of ordinary colleges rather than universities, for they have ideals of teaching in common with the former. Their organization, their desire to teach and to examine, and the graded course of instruction, make the better medical schools similar to the average colleges. Some of the colleges are more liberal and more nearly related to the university than are the best medical schools.

We must remember that departments are unable to grow and perform their duty best when their ideals are no higher than those of compulsory education. In their halls must live in the fullest degree the various sciences represented by them. There the science must also grow, and this is possible only with the banner of liberty over them, which would be most becoming in this country. We must always remember that it is with this banner over the German university that the greatest progress has been made; that embryology was there born simultaneously in the departments of anatomy, physiology and zoology; that histology appeared at the same time in the departments of anatomy, physiology and pathology; and that the greatest victory of modern medicine, bacteriology, is also to be credited to three departments—pathology, hygiene and botany.

We are now on the verge of a new development in medical progress and education in which the strongest support is demanded from all

[8] See, for instance, Helmholtz, "Akademische Freiheit," Berlin, 1878.

sides. We need capable men to lead, liberty in medical education to strengthen them and to develop their disciples and their successors; endowments sufficiently large to raise the professors above the level of schoolmasters and to make the departments they represent, in reality departments of a university.

MEDICINE AND THE UNIVERSITIES[1]

By Lewellys F. Barker, M.B.

I wish to spend the time you have courteously allotted to me to-night in making a plea for the better organization and endowment of the medical departments of universities. If you will permit me to refer in a few words to the character of the medical schools of the past and to outline to you some of the features of the medical schools of the present, I shall be the better able to make clear to you my opinion regarding some of the needs of the medical school of the future.

The Passing of the Proprietary Medical School

The majority of the medical schools in America have developed as proprietary medical schools. Usually a group of medical men, centering in one strong personality, formed a combination with two objects in view: (1) the education of young men in the medical art, (2) self-improvement and the advancement of their own standing in the profession and with the public. The course of instruction, brief at first, was first extended to two years, and then to three. It is now in most schools four years. The graded course was a relatively late feature. For many years only one course of lectures was given in the school. This course was repeated each year, so that if a student who attended all the lectures in his first year, came back for a second or a third year, he listened to the same lectures over again. The introduction of the graded course by the Chicago Medical College (now the Medical Department of the Northwestern University) was therefore a distinct step forward. The division of labor among the instructors became more marked, and the corps of instructors was correspondingly increased. The necessity, on the part of the student, for a grounding in subjects like anatomy and physiology, previous to clinical work, became apparent. Chemistry, histology, materia medica and pathology were subsequently added to the preliminary training, though the latter subject was taught for a long time chiefly in connection with the clinical work.

[1] An address delivered at the meeting of the Western Alumni of Johns Hopkins University, held at Chicago, February 28, 1902. Published in *American Medicine*, July 26, 1902.

There were no requirements of preliminary education for the students—or, if any, merely nominal ones. Many of the proprietary schools, whose whole income was derived from the fees of students, were able to pay all their expenses and to have besides a handsome surplus at the end of each year for division among the members of the staff. And aside from the profits of the school itself, official connection with the staff of a medical school came to be of distinct financial value to the practising physician or surgeon. The public, naturally, employed practitioners who were teaching in the medical schools. Also, young graduates of the medical school who got into difficulties in their own practise, usually called into consultation their former professors. So valuable, indeed, became this connection that some of the incorporated medical schools took advantage of the opportunity in an interesting way. The members of the corporation would agree to admit a practitioner to the teaching staff on payment of a certain sum of money. The cost of a professorship varied, of course, with the situation of the school and its standing in the community. I am informed that professorships may still be purchased in some of our medical schools, and that they are valued at as much as two thousand dollars per chair. The demand for chairs in such schools has been so great at times that a corporation could choose the better men among the applicants.

As long as the teaching in the medical schools was purely demonstrative the cost of medical education was at a minimum. Anatomy was the first subject to be taught other than in a demonstrative way. For as anatomic material became more plentiful, students dissected for themselves. The material was not, however, expensive, and the laboratories were of so crude a nature that very little money was expended on the workshop. The clinical teaching was done in hospitals and outpatient clinics—usually public institutions—and cost the corporation nothing. Students, perhaps, were required to pay a hospital fee. The hospitals did not belong to the medical schools, and it was accordingly necessary to include in the medical faculty those physicians and surgeons who had been fortunate enough or clever enough to secure appointments in the hospitals and dispensaries. Where these clinical institutions were in the hands of politicians, the best practitioners were not always on the staff.

When the microscope became an important factor in medical education in Europe, American students who had gone abroad for post-

graduate instruction came back full of enthusiasm for microscopic work, and began instruction in the use of the instrument in histology and pathology. It was very soon recognized that the medical school must offer extensive courses in normal and pathologic histology. This addition necessitated more than simple demonstration of microscopic preparations, although the instruction began in this way. It was soon found that the students must themselves do work with the microscope, and this, since laboratories in which microscopic work could be given and the microscopes and their accessories were expensive, involved a large increase in the budget. In addition, students doing such work require a great deal of personal attention, much more than the short time given by instructors under the lecture system. Very few practitioners had had the opportunity of perfecting themselves in microscopic technic, and the services of the men qualified to teach it were at a premium. Indeed, the demand became so great that certain men undertook especially to fit themselves for such work. The schools which offered the best facilities in laboratory work attracted the most students, and so competition arose among the proprietary schools to excel in this direction. Pathologic anatomy and histology now became important subjects, and at about the same time experimental physiology developed, so that it, with the other two, had to be given an important place in the curriculum. With the advent of Pasteur's discoveries and Koch's researches, bacteriology sprang suddenly into favor; and laboratories fitted out with thermostats, culture tubes, and oil-immersion lenses were everywhere demanded.

But this necessary laboratory instruction in physiology, histology, pathology and bacteriology made such demands upon the students that those without previous experience in chemistry, physics and biology were seriously handicapped. And since the standard of admission to medical schools was very low, the students rarely entered the medical school with such training, so that the medical schools themselves were compelled to try to teach at least some of these subjects in the first year of medicine.

The proprietary medical schools thus found themselves in a dilemma. For the enormous cost which accompanied these changes in the curriculum not only reduced the surplus, but wiped it out altogether, and, by those who introduced them, rapidly increasing deficits had to be faced. The fees of students in these schools were found utterly inadequate to

supply the money which the rapid change in teaching made necessary. Some relief had to be sought. Endowment for proprietary medical schools could scarcely be hoped for. The only relief, apparently, lay in a combination of the medical school, or at least a part of it, with the scientific departments of a university which received government aid or had private endowment. And so, between the proprietary schools and such universities, various arrangements were entered into. Sometimes a medical faculty was established in the university; sometimes an affiliation was agreed upon. In some schools the chemistry, physics and biology were taught in the university, all the other subjects remaining in the medical school.

To-day, however, it is regarded as imperative that anatomy, physiology, pathology and bacteriology, physiologic chemistry and pharmacology, be taught on a university basis. For each of these subjects requires the service of men who have made it their life-work. The kind of instruction which has to be given makes large demands upon the teacher's time; indeed a conscientious teacher of one of these fundamental sciences in a department of a university sometimes finds it difficult to get a sufficient amount of time to undertake research. Thus it has gradually come to pass that in the good medical schools those who teach the subjects mentioned no longer engage in the practise of medicine, but devote all of their time and strength to the teaching and investigation of the sciences which they represent.

The Pseudo-university School

The consent of a certain number of the universities to undertake the instruction of medical students in some of, or, in some places, all of the sciences fundamental to medicine having been gained, there speedily ensued such an enormous improvement in medical instruction in these institutions that the desirability of the move became quickly and widely recognized, and this not only by the medical profession, but by prospective students and by the public at large. The success of the schools combined or affiliated with the larger and better managed universities has been so pronounced that most proprietary schools having no such connection have tried everywhere to enter into some such arrangement. In certain instances it can not be denied that medical schools have sought rather the prestige of the connection than any material improvement in the courses of instruction. They are no more

to blame perhaps than are the universities that have been willing to receive them as their medical departments. In spite of the fact that medical educators are unanimous in the opinion that adequate medical instruction can not possibly be given when the fees of students alone are available as a budget, some of the poorer universities, and occasionally some of higher rank, have been willing to undertake the responsibility of medical faculties, provided they did not cost them anything financially, or only a relatively small sum. Such medical schools I should designate "pseudo-university schools."

The proprietary school, however, did excellent work in its day. Magnificent examples of self-sacrifice are to be met with in the records of the faculties of such schools. Especially when the demands of advancing science increased the cost of medical education do we find in them notable instances of generosity and unselfishness. When deficits began to appear, members of the faculty, instead of drawing salaries, recognizing what the school had done for them in increasing their practise and reputations, and having the welfare of medical education at heart, mulcted their own pockets to make the sheets balance. But now the period of usefulness of the proprietary school of medicine has gone. The conditions are such that its continuance is a menace rather than a help to the community. The pseudo-university schools are worse than the proprietary schools, for they are proprietary schools in disguise.

The Semi-university School

There is a third class of medical schools at the present time represented by six or eight of the best medical schools in the United States. This class I shall designate as that of the semi-university school. By this I mean that the subjects of the first two years are taught in the university, by university professors, who do not engage in the practise of medicine, but who give their whole time and energies to the teaching and investigation of the sciences which they represent. The laboratories of anatomy, physiology, pathology, etc., are installed in the same way as are the laboratories of physics, chemistry, zoology and botany. The professors and their assistants, running careers in these departments, are paid on the same scale as, or, on account of the difference in ratio of supply and demand, a little more liberally than, are the professors and assistants in the other science laboratories of the university.

Generous sums have in the better universities been provided for

laboratory furnishings and apparatus, models, books and other kinds of equipment. The fees of students are not even adequate to defray the annual running expenses, entirely aside from the cost of initial installation, in the departments of the first two years.

The results of making anatomy, physiology and pathology true university departments have been most satisfactory. Students are now able to obtain a thorough scientific training in these branches fundamental to clinical work. Formerly clinicians complained that the medical students came to them utterly unprepared as regards the structure and functions of the normal body and almost totally ignorant of the changes which take place in disease. Now, students accustomed to the well-regulated, thoroughly organized, rigorous work of the laboratories on approaching the clinical work sometimes complain of a lack of system in the teaching, of unsuitable arrangement of studies, of imperfect adjustment between departments, of insufficient attention to sequence of subjects, of unwarrantable waste of time. In some institutions they may even admit that an occasional clinical professor does not appear to be as familiar as he should be with the trend of modern work in anatomy, physiology, physiologic chemistry and pathology.

Especially gratifying as a result of the change made by the semi-university school have been the consequences for productive scholarship. Instead of the sterility which characterizes the departments of anatomy, physiology and pathology when they are manned by practitioners, in the semi-university schools they have become beehives of industry, centers of original investigation, and the last decennium has seen the birth of an American *Journal of Experimental Medicine,* an *American Journal of Physiology,* an *American Journal of Medical Research* and an *American Journal of Anatomy*—four scientific journals in which the contributions are rigidly limited to the publication of the results of original research!

The departments of the last two years, whether nominally included in the university or not, are situated entirely differently in these semi-university schools. All of the men who teach in these departments, or at least the majority of them, are men who are practising medicine, surgery, obstetrics, or some one of the specialties. The schools provide lecture-rooms, sometimes an outdoor clinic, and in the better ones clinical laboratories. In some of the schools a few of the younger men, especially in connection with the clinical laboratories, or as assistants to

the professors, are paid to give their whole time to the institution, and do not engage in practise. The professors themselves, however, are either not paid at all or are paid small sums, nearly always less than the remuneration which pertains to a university chair, and always too little to provide the professor with a living income. These professors are often successful practitioners, however, and make incomes varying from $5,000 to $25,000 per year, or even more. The universities seldom own hospitals. Or, if they have hospitals, they are, as a rule, small and totally inadequate to provide the clinical facilities necessary for the number of students taught. The professors in medicine, surgery and obstetrics usually have sufficient personal influence, or the school itself is influential enough, to permit them to utilize for teaching purposes the wards of various charity hospitals. The hospitals thus utilized have nearly all been built for a specific purpose, namely, to provide beds and treatment for charity patients in the cheapest possible way. The majority of them are political institutions, with all the faults of administration thereto pertaining. Even when the institutions are privately endowed, as long as the management is not in the hands of the university itself, innumerable and often previously inconceivable difficulties are put in the way of clinical teachers. Continuity of service, for instance, is rarely possible, and such a thing as a graded staff, directly responsible to each professor—an arrangement absolutely indispensable for satisfactory clinical work—is almost unknown.

It is obvious that if those who teach the clinical subjects have to make their living from practise they will be compelled to direct their activities so as not to interfere with practise. When one considers the amount of time and energy which the patients of a successful city practitioner use up, when one remembers the large bibliography in English, French and German pertaining to the clinical branches which must be waded through weekly and monthly to keep pace with one's subject, and when one thinks of the discouraging conditions in the hospitals in which these clinicians are compelled to visit, he is forced to marvel at the excellent work which is daily being accomplished, at the closeness in touch with the progress of their subject maintained by the more strenuous of these men, and at the fact that some of them, in spite of all these unfavorable circumstances, actually make contributions to the advance of science by their original work. It says much for the energy and character of the men who are attracted by clinical medicine, sur-

gery and obstetrics in this country. If so much can be accomplished under such adverse circumstances, what might not be done by such men if the subjects of the last two years were placed upon a *real* university basis? I should like to see what the result would be if men with these capacities were bred to university careers, were placed in charge of hospitals especially constructed and endowed for university purposes, and were sufficiently paid to permit them to devote their whole time and strength to teaching and investigating in such hospitals.

A Real University School

If one attempts to portray the characters of a school of medicine developed throughout according to true university ideals he will find it necessary to depict conditions which, as yet, exist nowhere in completeness. In a modern university an essential feature is the combination of the *academia* with the *schola*. The university must be a center of original research, as well as a place of instruction. An institution which attempts no more than the imparting of knowledge already acquired to its students is not worthy of the name of university. It is merely a college or seminary. A true university is made up of a group of scholars who are not only familiar with the results of previous investigations, but who, endowed with unusual capacities and skilled in the methodology of their respective sciences, invade new territories, searching diligently for new facts. Methods already devised are used when they are sufficient; new methods are invented when old ones fail. Each scholar works for the sake of truth in his own department. He does not permit himself to consider too attentively the applicability of the truths he discovers to conditions belonging to other departments of knowledge. He may not be too regardful of the compatibility of a new fact with the preconceived ideas held by himself or by others. He will do well not to spend too much time thinking of the effect of a new fact upon the desires or the fears of the people. He must have a profound belief in the ultimate value of truth, no matter how unpalatable it may be, or how useless it may seem to those who live at the time it is found out.

Each leader in a department of a true university is both a teacher and an investigator. The really great teachers have always been investigators. The really great investigators have always been teachers, though not always, perhaps, of large groups of students, nor always, it

must be admitted, in their own generation. It is highly desirable that the two faculties of teaching and discovering be combined in every university professor. There may be a place for the non-investigating teacher in a college or seminary, but he is certainly out of his sphere as the leader of a department in a university. The great investigator, on the other hand, who can not teach students directly, may profitably be housed and cared for in a university for the sake of the contributions which he will make to knowledge and the prestige his work will bring to the institution, but the department in which he works should also be represented by other men who can both investigate and teach. I am convinced that the influence, for any considerable length of time, of a non-investigating teacher can not fail to be actually harmful to a student. The student may possibly acquire large stores of information, but he will not make progress in independent work or in independent thought; indeed his powers in this direction will be inhibited, if not in time wholly obliterated. No less pernicious to the student would be the effect of an investigator whose personality is repellent and non-sympathetic and who has little or no capacity to interest students in his subject, to inspire their enthusiasm for work, or to train them in accurate observation, sound reasoning and vivid imagination.

If these views of what a university professor should be hold for the faculties of arts, literature and science—and it will, I believe, be generally granted that they do—why should they not also hold good for the professional faculties of law and medicine? Surely there is need in these faculties for professors of the same high type.

It is generally taken for granted that in the philosophic faculty of a university a professor shall give the whole of his time and all of his strength (aside from necessary recreation) to work for the university. The professor of economics does not give a part of his time to the university and the other part to the financing of city banks. The professor of mathematics would scarcely be permitted to give his forenoons to calculus, quaternions or the teaching of "groups" in the class-room, and his afternoons to the work of actuary for a transcontinental railway, or to the calculation of stresses and strains for a bridge manufacturer; nor would the university retain as its professor of chemistry one who divided his time between the university laboratory, on the one hand, and a factory for the preparation of aniline dyes, or a huge establishment for the manufacture of drugs in a commercial way, on the other. Imagine

the condition which would exist if the university said to its professor of economics: "We shall be glad to have you as our professor of this subject, provided you are willing to do the teaching we ask of you without direct remuneration. Your position in the university will make you so well and favorably known, that you will easily be able to secure financial responsibilities in the city which will give you a far larger income than we could afford to pay you." Or if the president and trustees made a proposition to the professor of chemistry that he be paid $1,500 per year to take charge of the teaching and investigation in the chemic laboratories, it being pointed out to him that the prestige of a university professorship will enable him to secure lucrative positions as commercial chemist to four or five manufacturing concerns in the city in which he lives, or as analyst to baking-powder companies and manufacturers of pure food preparations, some of the trustees taking the stand that the intimate contact thus gained with chemistry as practically applied in the business world is not only desirable for the professor, but absolutely essential in order that his influence upon his students may not be too academic! Which, think you, the university interests or the other interests, would get the lion's share of the time and energy of these professors, especially if they happened to have families with tastes as expensive as those of the average American family of the better class? What think you would be the rate of progress in original work in the sciences of political economy and chemistry in a university so constituted? And yet there is not a medical faculty in a university anywhere in America where this plan is not followed, at least for some of the chairs. The law faculties have fared somewhat better, perhaps, but I am told that the condition obtains also in the majority of these. Until this is wholly changed we can scarcely hope for the disappearance of that opprobrium which, it can not be denied, attaches to the so-called professional faculties of our universities. Until a new régime is entered upon, we must, for these faculties, fain be content with work less in quantity and poorer in quality than is consistent with the ideals and dignity of a true university.

It is a rather prevalent opinion that the reason the philosophical faculties of universities have been regarded as of higher standing than the professional faculties and the faculties of technical schools is to be found entirely in that aristocratic prejudice which favors traditional "learning" and holds itself aloof from science, and especially from

science as applied in professional and industrial life. I have as little sympathy as any one with those narrow-minded academicians who believe that the only learning and the only culture worthy of the name are to be gained by a study of the ancient languages and literatures. Indeed, I unhesitatingly join hands with those who maintain that any academic training which does not include the inculcation of the "fair, faithful and fearless spirit" of modern scientific inquiry fails of the best purpose of education. What is more, I am convinced that a reasonable admixture of natural-science studies, even if chosen from the domain of applied science, with the courses in languages, literature, history and philosophy, will yield cultural results of a far higher order than can be obtained where programs from which natural science is excluded are followed. For only through the study of the natural sciences can we escape that dominant, though unwitting egoism which makes man the center of the universe. Our whole education tends too much to distort the human relation. "Man so readily deifies himself, and so gladly permits others to deify him: he occupies himself preferably with himself, with his own intellect and its products, he calls his own intellect divine; takes pleasure in worshiping his own image and imagines that at the same time he is exhibiting a proper degree of humility." It is with great difficulty that human beings resign themselves to the scientific view of man and the universe. It is not easy at first, as Billroth says, to admit that even the greatest human being is a mere atom compared with the totality of natural phenomena, or to hear the whole human race described as but one group of animals, active but for a relatively short time upon the earth's surface, and, in comparison to the whole universe, vanishing almost into nothing. "Man may willingly humble himself before his God, but he always values himself much higher than the whole of nature." There is a side of culture which only the study of the natural sciences can give. A sanity and a balance are derivable from them which can scarcely fail to be lacking when the so-called "humanities" only are studied.

Though it may be true that prejudice born of the old monastic influence still shackles the universities, and that there has been in the past a "discrimination among learnings," I can not believe that it is lack of democracy *alone,* or predilection for tradition *alone,* which accounts for the slowness with which in the first place so-called pure science and later the scientific professions gained recognition among

the people and in the universities, or for the opprobrium that undoubtedly does attach still in many minds to the terms professional school or technical school, when compared with the school of philosophy. The cause lay much deeper. It was necessary for the professional schools and the technical schools to win their spurs. So long as natural science remained merely the recreation of the dilettante, so long as medicine continued to be chiefly an empiric art, and technology the passing on of rule of thumb, these subjects were not coequal with their elder sister. No people began its culture with the exact study of the natural sciences; these could come to development only after the prolonged influence of language, art, religion, law and politics. So soon as physics, chemistry and biology began to make the tremendous strides forward which characterized the last century they were taken out of the medical faculties and incorporated in the philosophic faculties of the universities with the happy results familiar to all.

Recently, applied science has won its place. The enormous expansion of commerce and industry has compelled the establishment of great technical schools. The old method of apprenticeship no longer suffices for the training of men. It has become necessary to save time and energy, and to make the instruction more extensive and more thorough by education in institutions dedicated to applied sciences. The inventive mechanic, the engineer and the electrician have revolutionized the world within our own memories; if we live out our threescore and ten we may, perhaps, be permitted to witness even greater transformations. In the schools of engineering, not only are the known applications of science taught, but brilliant minds are constantly at work devising ever new and still more wonderful applications. America, especially, has reason to be proud of the advances she has made in technologic education. A foreigner commenting upon our educational system has made the statement that "the engineering profession is to-day, upon the whole, the best educated in America." The degree of doctor of engineering from a good university or institute of technology commands full respect. I shrink from comparing it with the degree of doctor of medicine given by many of our universities or medical schools. The governments of Germany and Austria have made "the doctorates of engineering and of the applied sciences, and the institutions permitted to confer them, coequal with the doctorates of philosophy and their conferring universities." The head of the great

German Polytechnicum has been made a Rector Magnificus, proof enough that the democracy of learning is gaining ground.[2]

The way to get the highest recognition is to deserve it; the way to get rid of the opprobrium attaching to the professional schools is to remove the cause of it. In medicine this cause is fast disappearing. Anatomy, physiology and pathology have followed physics, chemistry and biology into the university. Large and well-equipped laboratories and libraries are devoted to these subjects. Large amounts of money have been given, so that the professors and their assistants, though as yet inadequately remunerated, are sufficiently paid to permit men who will despise certain of the delights of life and live laborious days to follow these subjects as careers. Students are taught, and important discoveries are being made in these branches. The physiologist is as fully recognized as the philologist. The men and their subjects are on an equality, not because they have been made so by edict of sovereign or ruling of university presidents, or vote of trustees, but because they really *are* so. There is no reason why internal medicine, surgery, obstetrics and certain other branches should not be similarly elevated; on the contrary, for the sake of people who need help in time of illness, for the sake of the medical profession, on account of our universities and for the prestige of the science of the nation, there is every reason for that elevation. And this would speedily be brought about if universities and their benefactors fully understood the situation.

How can a Semi-university School be Transformed into a Real University School?

By putting all the departments, at any rate all the principal departments, on a true university basis. To do this several things are necessary.

In the first place, a very large sum of money would be required, for the university would have to build and equip hospitals of its own, arranged on an entirely different plan from that adopted in ordinary charity hospitals. The hospital for internal medicine would be built with the definite idea in view of teaching students and of making original researches into the nature, causes and treatment of disease, in addition to caring for a certain number of patients. In other words, in addition to the facilities offered by any good hospital, the university

[2] Cf. Thurston, R. H., "The College-man as Leader in the World's Work," *Popular Science Monthly*, Vol. IX., 1902, pp. 346–359.

hospital for medicine would have to house a *university department* of medicine with its teaching and research laboratories. A second hospital would do the same for surgery; a third for obstetrics. Two million dollars for each of these hospitals would not be an excessive sum to make the initial installment and to endow the university department. In order to secure such a large amount of money it is obvious that university presidents and boards of trustees must be fully convinced of its necessity, for only when this is the case will wealthy men be willing to contribute such immense amounts to the universities for this specific purpose.

If such hospitals could be obtained, and such professorships endowed, the men engaged to work in them should be chosen with the same care as to talents, attainments and personality as is exercised in the choice of any other professor in the university. The men chosen should, like other university professors, give their whole time and energy to the work of the university, to teaching in the hospitals and to investigating in the hospitals. They should be men who have already made important contributions to knowledge and who are likely to continue doing so for the next twenty years. They should be well paid by the university. They should not engage in private practise, even if the university has to pay them double the ordinary salary now paid to a university professor to retain them wholly in the university work. If any patients at all, outside of the hospitals, were seen in consultation, and there is some force in the argument that the well-to-do public should at least in some rare and difficult cases be permitted to profit by the opinion and advice of the university professor, the fees received from them might be contributed to the budgets of the hospitals themselves, in order to remove all temptation from the staff.

The objection is sometimes raised that university professors who gave their whole time to teaching and investigating in hospitals would not come into contact in hospitals and dispensaries with the kind of patients and the types of diseases which are met with by the practitioner in private practise, and that accordingly the student would not be taught how to deal with private patients nor how to recognize and treat the cases which he has actually to deal with later himself. This argument appears plausible until it is more closely examined. The character of hospital patients is gradually changing and the clinician who confines himself to work in hospital wards and dispensaries does

actually in these latter days see many more of those people and of those varieties of complaints previously seldom seen outside of family practise. On the other hand, in a medical college in which the clinical professors engage in private practise, the students are not taken by their teachers into the homes of the patients, the private patients are not shown and the "private-practise" diseases are not demonstrated or studied in any practical way. The influence of his "private practise" may be visible, perhaps, in some special *savoir faire* manifested by the instructor in dealing with patients; too often it reveals itself in the more superficial examination of the patient, the more hurried consideration of the case, the less rigorously established diagnosis and the writing of a prescription *ut aliquid fiat,* which the exigencies of private practise are said sometimes to entail. Even if it were granted—and I, for one, am ready to grant it—that something difficultly definable but of real value to the learner emanated from the teacher who spends a large portion of his time in private practise outside of hospitals, which is lacking in the professor who gives his whole time and energies to the patients in the university hospitals and work in the laboratories adjacent to the wards, would it be comparable with the increase in scientific spirit which the student might reasonably be expected to gain from contact with a professor who, besides having the capacity for the best kind of work, has the time, energies and opportunities to penetrate into the innermost secrets of disease in a manner precluded by the demands of private practise? If we had to give up one influence or the other, would there be any doubt as to which we could the more safely disregard? *But we need not be deprived of either influence, for in large cities both should be available and the students should be permitted to profit by both.*

It is not necessary or desirable (aside from being impossible) that a student, during the two or three years spent in clinical work in the medical school, should see all kinds of diseases, or even hear of all the symptoms or of all the methods of treatment which have been advised. It is important that he should be taught systematic methods of accurate observation and investigation; that he should be taught how to get at and how to relate the experiences of his predecessors in interpreting his findings, how to make judicious prophecies for the future from a consideration of the past, and how to plan out a rational mode of treatment. He needs thorough, conscientious drill in the fundamental

methods of examination, preferably on not too large a number of patients, for a long time before he views the kaleidoscopic transformations of the "20 patients per hour" clinic, and is treated to imposing demonstrations in "snap-shot" medical diagnosis or spectacular amphitheater surgery. *Routine lernt man allzuschnell.*

I would not be misunderstood in this matter. No one values perhaps more highly than I the rich and varied experience of the really great practitioner of private practise, nor is any one more cognizant of the fact that many busy practitioners are enthusiastic, careful, thorough, methodical teachers. *There is a proper place for this type of man, as well as for the university professor, in a real university school. The finding of that place is all-important for the future welfare of medicine.* The student at the beginning of his clinical work should be thoroughly drilled in all the methods of examination, and should study a few cases laboriously, applying with strict rigor the methods he has learned; later he might more safely be permitted rapidly to widen his clinical experience by being introduced to a greater number and a greater variety of patients. My own opinion is that the work of the present third year might be taught by professors and instructors who give their whole time to university hospitals, and that those associated clinical professors and instructors who also engage in private practise might teach in other hospitals in the last year of the medical student's course. It is very desirable that the better practitioners should continue to visit in hospitals for the good of themselves and of their patients, as well as for the good of medical students. University hospitals for research will of necessity be few in number, and will by no means replace the hospitals which at present exist. Particularly in the clinical specialties must the private practitioner be retained as a teacher, for but few universities will have the endowment necessary to maintain full university chairs in clinical departments other than those of medicine, surgery, obstetrics and perhaps psychiatry.

The great discoveries which have been made in practical medicine recently have resulted largely from the introduction of the experimental method. There is no doubt in my mind that it is to experimental medicine that we must look for the advances of the future. Had it not been for Pasteur's brilliant discoveries and the ingenious methods devised by Koch, we should not have had Lister's work and the aseptic surgery of to-day, nor would a disease like diphtheria, formerly so fatal,

have been robbed of its terrors through the introduction of an antitoxin. But experimentation ought not to be confined to those physiologists and pathologists who are not clinicians. What we need above all at this time are physicians and surgeons trained in physiology and pathology who will spend a part of their time in careful observation in the wards and over the operating table; who will there collect facts which will give them ideas to be submitted to experimental test, and who, during the rest of their time, will go down into the laboratories adjacent to the wards and actually make these experiments. The men who do this should give their whole time to the university.

Will the money necessary for the introduction of research hospitals and university clinical departments be available? I believe firmly that it will, and that, too, in the very near future. How many a fond and wealthy parent fifty years ago would have endowed one or more great hospitals could he have saved the life of his child dying of virulent diphtheria! The organization of an Institute for Medical Research in New York, and of a Memorial Institute for the Investigation of Infectious Diseases in Chicago, is a sign of the times. The same is true of the Institute for Experimental Therapy in Frankfort, and a number of others which I could name. The place for such institutes is in the medical faculties of the universities. Wealthy philanthropists are recognizing the value of the methods of research. There is no lack of money which could be made available for the founding of university hospitals for research and for the maintenance of true university departments of medicine, surgery, obstetrics and psychiatry, provided those in whose hands it lies awaiting distribution can be convinced that it will be used to the best purposes.

I ask the cooperation of the alumni of this university in influencing university faculties and university presidents, the public and philanthropists to hasten the introduction of real university medical schools in the different centers in this country. The chief cause of delay, in most institutions, lies with the university authorities. They are often more difficult to convince than are their financial benefactors. University authorities are too prone to magnify the importance of obtaining large numbers of students rather than to emphasize the desirability of an elevation of standards. They do not always recognize fully the needs of research, and are accordingly timid in their requests for money for investigation, though they are ever ready to demand money to teach

more students. If this fear continues, the universities will lose the research institutions, for philanthropists will endow them as independent foundations. Above all should the means for research be afforded to the professional faculties. Poor professional faculties drag down the philosophic faculties; adequate schools of medicine and law lend prestige to the school of philosophy. Were there any tendency to internecine jealousies among the various faculties of a university, self-interest alone should be sufficient to suppress it. What is to the advantage of one faculty will not fail to help the others. Each faculty should vie with the others in working for the welfare of the whole university. Each faculty, therefore, will demand that all the faculties are provided with the facilities for seeking the truth according to the most rigorous methods, and independent of its apparent use or harm. The more intense the desire of the people for truth and clearness becomes, the more pressing will this demand grow.

SOME TENDENCIES IN MEDICAL EDUCATION IN THE UNITED STATES[1]

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That brilliant and humorous journalist-novelist, Mr. Arnold Bennett, in his essay on "Success" says: "I feel that it is as dangerous to tell the truth about success as it is to tell the truth about the United States; but being thoroughly accustomed to the whistle of bullets round my head, I will nevertheless try." Whatever grain of fact there may be in his allusion, certain it is that in the United States themselves there is a strong tendency at the present time to try to tell the whole truth about medical conditions there. As regards medical education, the men who are really interested in the matter are making no attempt to blink the facts. Those who write and speak seem determined to deal with the subject in a thorough and candid manner. The discussion has led, and is leading, to marked changes in the standards and circumstances of medical instruction, medical research and medical practise "on the other side of the line." To some of the truth concerning medical conditions, and to some of the burning questions at issue, I desire to point.

The Passing of the Inferior Medical Schools

If you compare medical education in the United States twenty years ago with what it is to-day, you can not help but be impressed with the remarkable change which has taken place. The period has witnessed a reform which is noteworthy in history. During the past decade, especially, there has been a steady decrease in the number of inferior medical schools and an elevation of standards in the better schools. The country has passed rapidly from a stage in which the proprietary medical school was dominant to one in which all, or nearly all, of the better medical schools are the medical departments of universities.

[1] Based on remarks made at the convocation exercises at McGill University, Montreal, June 5, 1911. Published in the *Journal of the American Medical Association*, 1911. [The article in the *Journal* is abridged.]

It was not easy to bring such a change about. Every reform entails hardships; attempts at betterment invariably excite some animosity and antagonism. It says much for the spirit of the men in the medical profession and in the faculties of the medical schools that the majority of them have kept in mind the welfare of the profession, of medical education and of human service, and have been so ready to sacrifice their private interests when such self-denial was demanded.

Reduction in the Number of Medical Schools

The total number of medical schools in the United States is still being rapidly reduced. This reduction is taking place in two ways: first, by extinction of the most unfit; and, second, by the merging of numbers of feebler schools into larger and more efficient institutions. In 1904 there were 166 medical colleges in the United States. Within the succeeding lustrum the purificative movement had made such progress that in 1909, though twenty-five new medical schools had been organized, forty-three had been closed, sixteen by extinction and the balance by merger with other schools. This process of suppression of schools and of amalgamation of schools has been continuing since, and it is hoped that the examples set by the medical schools in Louisville, Kentucky, and in Cincinnati may be followed, especially in large cities like Baltimore, Chicago and Philadelphia. The absurdity of having more than a dozen medical schools in a city like Chicago is obvious. Imagine the medical state of Berlin, Vienna or Paris were the powers of medical instruction there similarly disintegrated!

Increased Requirements for Admission. Elevation of Standards in Teaching

This reduction in the number of medical schools with survival of the better has been due less to direct attacks on the poorer schools than to a rapid elevation of the standards of admission to, and improvement of the teaching in, the better institutions. Some day the history of this advance should be carefully written. Intricate and complex as have been the factors of this progress, we may easily, on attention, disengage the main influences which have been responsible. Among them, it is now generally admitted, were (1) the initiation of a graded course as far back as 1859 by the medical department of Northwestern University in Chicago, (2) the adoption of this and the gradual increase

of admission requirements and improvement of the curriculum in which schools like Harvard set the pace and, further, (3) the step taken in 1893 in the organization of the Johns Hopkins Medical School. The latter, an integral part of a strong university, opening its doors to students in that year, made several departures from established custom. It announced that candidates must present, as a prerequisite for admission, evidence of having had an education corresponding to that required for the baccalaureate degree in a good college of liberal arts; in addition, either when working toward this degree or subsequently, a year's laboratory training in physics, chemistry and biology must have been completed and a fair reading knowledge of the French and German languages acquired. With an endowment, part of which was given on condition that these requirements for admission be maintained and that women be admitted on equal terms with men, this school was able not only to establish well-equipped laboratories of anatomy, physiology and pharmacology in addition to the laboratory of pathology which had been built earlier, but to secure a group of men for the non-clinical chairs who had been trained especially in their respective sciences, who had no desire to practise medicine and who were willing, on salary, to devote their whole time and energies to instruction and research. More important still, an endowed hospital, which had been organized a few years earlier, stood at the disposal of the medical school. In the donor's will it had been expressly stated that the hospital should "ultimately form a part of the medical school of the university," and, accordingly, the professors in the clinical branches in the medical school are, simultaneously, the chief of the clinics in the hospital, and the professor of pathology the head of the pathologic laboratory to which the clínics send their dead.

Since that time the medical departments of many other universities have increased their equipment and provided larger means for professorships, especially in the non-clinical branches; several schools now require a college degree for admission; no less than twenty-seven schools demand as a minimum for entrance two or more years of work in a college of liberal arts—a gratifying showing when it is recalled that up to 1904 less than two per cent. of all medical colleges required more than a high-school education as preparation. The success of the better schools, the enthusiasm of the students trained in them, the opportunities which have opened up for these students after graduation,

the scientific investigations leading to publication which have been carried on—all have contributed to spur other medical schools in different parts of the country to emulate the examples set.

There have been two main difficulties: (1) the financial one of equipping the expensive laboratories of anatomy, physiology and pathology and paying the staff sufficient amounts to permit them to devote their whole time and energies to the work; and (2) the absence of endowed hospitals under the control of medical schools or universities, into the wards, dispensaries and laboratories of which students could be taken actually to participate in the routine work of diagnosis and treatment.

Lively discussions on (1) medical education, (2) the preliminary requirements therefor, (3) the endowments needed, (4) the character of the staff necessary, (5) the importance of university supervision and (6) the necessity of laboratory and bedside instruction instead of preponderantly didactic teaching, did much to spread a new gospel. These debates were carried on by the faculties of the medical colleges themselves, by the associations of medical colleges, by the associations of American universities and by the members of the various state examining boards.

Agencies Influential for Reform

One of the most potent of the agencies for the elevation of standards has been the Council on Medical Education of the American Medical Association, a permanent committee of six men,[3] appointed expressly for the purpose of improving medical education and making it more uniform throughout the whole country.

One interested in medical education will have difficulty in finding more interesting reading than the annual reports of the conferences held since 1905 by this council. The discussions on admission requirements, on curricula, on university relationship and on the functions of state boards, and the reports made, (1) on the standing of the various medical colleges, based on the failures of their graduates in examinations before state boards, and (2) on the results of a personal inspection of all medical schools in the United States, made by members of the council, have had an effective influence in awakening the profession to the pedagogic problems which confront it, and, especially, to the desirability of speedy and radical reform. The grouping of medical

[3] Dr. Bevan, chairman; Dr. Colwell, secretary.

schools by this council into "acceptable" colleges, "conditioned" colleges and "rejected" colleges may be adduced in illustration of methods salutary in results.

The council has performed its work almost wholly through the cultivation of medical opinion; it simply gives publicity to the information which it collects. It has no power whatever to dictate to medical schools or to set standards either for the schools or for the state examining boards, but it has so deliberately and successfully, through the currency given to the results of its inquiries, worked on the collective medical mind in the United States, that a moral pressure, irresistible in its coercive force, has come to be exerted. A school, for example, which is heralded in the over 50,000 copies of *The Journal* of the American Medical Association as one which turns out graduates of whom more than 20 per cent. fail at the state licensing examinations, or another, which, after personal and unbiased inspection by members of the council, is classified as a "rejected" school, has a sealed fate.

The council has been none the less successful for having avoided Utopian attempts; it has been satisfied with a gradual, though steady, stride toward attainable ideals. It recognizes the manifold difficulties of the pedagogic situation, is aware of the necessity of taking time, of educating those concerned and, especially, of the indispensableness of endowment from the state, or from private funds, if desired reforms are to be instituted.

Another agency which has been active and effective in the attempt to help on the reconstruction of medical schools in the United States is the Carnegie Foundation for the Advancement of Teaching, which, in 1908, with Mr. Pritchett as president, authorized Mr. Abraham Flexner to study and report on the various American schools of medicine and law. Since the year 1876, when the Vienna surgeon, Billroth, published his "Ueber das Lehren und Lernen der medicinischen Wissenschaften," the monograph by Abraham Flexner[8] is, without doubt, the most important single contribution which has been made to the bibliography of medical education. The study and report were made on the assumption that medical colleges and the medical departments of universities must now be regarded as public-service corporations, and that the public is entitled to know about their administration and development, on both the financial and educational sides, for only

[8] Flexner, A., "Medical Education in the United States and Canada," a report to the Carnegie Foundation for the Advancement of Teaching, 1910.

through a reasonable publicity can progress in medical education be hoped for.

The report contains a history of medical education in the United States and Canada, comments on its present status, gives a forecast of possible progress in the future and describes more or less in detail each medical school in existence in the various states and in the Canadian provinces at the time it was made. Mr. Flexner concludes that during the past quarter of a century there has been an enormous over-production of uneducated and badly trained medical practitioners, and that this over-production of poorly trained men is mainly due to the existence of a great number of "commercial" schools attracting into the study of medicine unprepared boys who should have taken up industrial occupations. The poorer schools have failed, it is asserted, to appreciate the remarkable advance which the better schools have made and they underestimate the amount of money required to defray the expense of teaching by modern methods. Stress is laid on the fact that a hospital under complete educational control is as necessary to a medical school as is a laboratory of chemistry or pathology. A great reduction in the number of medical schools is recommended, better equipment and better conduct asked of those that remain, and the graduation from each of fewer physicians, but of better quality, demanded. Methods of properly articulating the medical school with the other parts of a university and with the general system of education are outlined. The university which is willing to retain a low-grade professional school for the sake of its institutional completeness is sharply censured. Further, though the impossibility of suddenly bringing all the persisting schools up to praiseworthy standards is recognized, it is urged that if a school can not rise to a certain minimum of educational requirement it should cease to exist, for it will injure and not help civilization.

The tone of this bulletin is frankly that of "shirt-sleeve diplomacy"; by some, its statements have been regarded as unnecessarily harsh and stringent; indeed, the question has been raised by at least one of the schools most severely criticized whether some of its statements might not be so defamatory as to give grounds for legal action for damage to reputation. But, however one may feel as to the relative desirability or success of the method of persuasion by praising the best and the method of compulsion by brandishing the "big stick," certain it is that this report was made only after extensive investigation and pro-

longed consideration and that it has exerted, in the brief interval since its appearance, an immense influence for good on the faculties of medical schools, on members of the medical profession and, through the newspapers, on the general public.

Through the various influences above mentioned inferior medical schools are rapidly being weeded out and the schools left are steadily being improved. The nation has set itself resolutely to the task of reconstruction and it will not rest satisfied until its medical schools have reached a degree of efficiency and attained to a power of public service which will bear favorable comparison with similar institutions anywhere in the world.

Position of and Some Tendencies in the Non-clinical Departments

On examination of the non-clinical departments of the better medical schools in the United States it will be seen that a definite policy has been established; the principles of this policy must sooner or later be observed by every medical school which hopes that its conduct may be held in good repute.

The Policy Established

The essentials of the policy include: (1) commodious laboratories equipped with all modern appliances for teaching and investigation in anatomy, physiology, pharmacology, biochemistry and pathology, (2) "full-time" professors with, for the more part, "full-time" assistants, trained or undergoing thorough training in these fundamental disciplines, men who are enthusiastic teachers and have a zest for, and success in, prosecuting original inquiries, and (3) an annual budget at the disposition of the staff adequate for improvement of equipments, for supplies and expenses and for the services of janitors, clerks and mechanical assistants. These departments are, therefore, not only places in which well-organized courses of instruction for medical students are offered; they are also centers in which knowledge is seethingly advanced.

Under this policy the non-clinical departments are flourishing. Glance through "American Men of Science" and make lists of those who have been led to cultivate these fields and have been notably successful in the work. You find an imposing array. Look over the journals, most recently founded, devoted to the different subjects, and

the proceedings of the scientific societies, and you will be gratified to find how speedily and notably knowledge has been and is being increased.

The best American work is receiving adequate foreign recognition, and while but few European students have thus far been attracted to American non-clinical laboratories for work, the stream of students which formerly flowed in the other direction has to a large extent ceased.

Dangers Threatening the Non-clinical Departments

The non-clinical chairs in the medical schools may be to a certain extent, however, in danger. The possibility of evil has arisen not at all through hostile intention, but rather through certain conditions, partly external, partly internal, which may place them in a trying situation. Of these conditions I shall refer now only to three, viz., (1) the rise of institutions devoted solely to research, (2) the rapid formation of medical faculties in state universities, and (3) the pecuniary penalty attaching to chairs on a "university basis."

The Rise of Institutes for Research

In both Europe and America, men of wealth on the one hand and governmental departments on the other, impatient for science to progress, have been endowing institutes devoted purely to investigation in the medical sciences, free from any necessity of teaching. The Pasteur Institute of Paris is a notable example; the Institute for Infectious Diseases and the Laboratory of the Government Health Office in Berlin and Ehrlich's Institute for Experimental Therapy in Frankfort-am-Main are German instances; in the United States may be mentioned the laboratories for investigation of cancer, the government laboratories for medical investigation in the Army and in the Marine-Hospital Service in Washington, The Rockefeller Institute for Medical Research in New York, the Carnegie Laboratory for the Study of Nutrition in Boston, the Memorial Institute for Infectious Diseases in Chicago, the Sprague Laboratory for Medical Research in the same city, the Phipps Institute for Tuberculosis in Philadelphia, the Wistar Institute of Anatomy in the same city and the Cushing Laboratory of Experimental Medicine in Cleveland. Such research institutions give unusual facilities for the pursuit of original inquiries; by virtue of this fact and of their large endowments they permit of larger rewards in the way of opportunity for work, fame and salary than are possible in ordinary

university positions. As a result able and distinguished investigators who otherwise would have been available for the medical faculties cease to be accessible to them; though the sciences themselves enjoy enrichment—undoubtedly these institutions are fully justifying their creation—the strength and vitality of the school-corps is correspondingly depleted. When possible, such research institutions should be placed contiguous to the buildings of a medical school, in order that the latter, even if separately administered, may benefit by their atmosphere. What a pity that the universities have been so short-sighted that they have not foreseen *the desirability and ultimate necessity of a division of labor in the non-clinical departments among professors whose function is predominantly teaching, and professors whose function is predominantly investigation!*

The Large and Sudden Demand for Professors

The second condition, the rapid formation of medical faculties in state universities, as well as the fusion of groups of schools into single stronger schools, has created a demand for a larger number of so-called "whole-time," non-practitioner professors of anatomy, physiology, pathology, etc. This demand has been greater than could be supplied. Only a few men adequately prepared for high positions have been trained; moreover, in many of the institutions, the positions, though high in rank, are still low in facilities and salary. In time, the public will become sufficiently educated to make proper provisions in the state universities for equipment and salaries. As yet, in only a few state institutions can it be said that this has been done. The effect likely to be produced sooner or later can be foreseen. There is danger that the cradle of the science nurseries will be robbed. Many lusty infants might, despite their premature parting from parental props, grow speedily and satisfactorily to adulthood, leaping as it were over adolescence, but in some instances, surely, we would see an arrested development. Thus, through the exit at the top of many of the best and through the entrance at the bottom of too many immature and partially trained, the high standards thus far maintained for the non-clinical chairs run some risk of depreciation. At present, positions, such as they are, can be obtained too easily; the period of training is so shortened as to make the attainment of a high grade of scholarship difficult. There is the dangerous possibility, too, of promoting to full

professorship men of mediocre talent, who, in a longer and more exacting discipline, would find their true academic level, or would gradually be weeded out in a competition in which the prizes were larger and the number of intellectually superior contestants more extended.

The Financial Status of the Professor

And, thirdly, perhaps even a graver matter, because it affects not only the occupants of the non-clinical chairs of the medical faculties, but those of the chairs in the colleges of liberal arts as well, is the financial status of the professor in the United States. This important question has, as far as colleges and universities in general are concerned, been made a topic of especial study by the Carnegie Foundation for the Advancement of Teaching, and the results of the study have been published in its Bulletin II. (1908). In 100 leading colleges of the United States and Canada the average salary of the full professors varies from $1,350 to $4,500, the average of all being about $2,500 per year. There are no large financial prizes that can be looked forward to anywhere, the maximum salary being $7,000 or $8,000, and only a very few places yield this. If larger salaries were given anywhere, even though the chairs enjoying them were few, the larger material potentialities of the professor's calling might exert a favorable influence. There are thirty-five institutions known as colleges in which the average salary for full professors is less than $500 per year. The average salary for full professors in the Johns Hopkins University is stated to be $3,184.

Of course in professional and in engineering schools the professors' salaries are somewhat higher than in the arts departments. But the maximum salary for a non-clinical chair of a medical department, except possibly in New York City, is, as far as I know, $5,000. The average salary in the twenty best medical schools would doubtless fall far below this level. It is to be remembered, of course, that a $3,000 salary in Ann Arbor will go perhaps as far as, or farther than, a $5,000 salary in Chicago. The occupants of non-clinical chairs like those of the chairs in the arts departments have little means of supplementing their salaries by outside work. Some of them do executive work which yields small additional emoluments; some write text-books which, if successful, bring in a modest amount in royalties; now and then a professor receives extra pay as a member of a federal, state or municipal com-

mission of experts. There is no income, or very little, from consultation practise, for anatomists, physiologists and pathologists have but rarely had the clinical training necessary to make them expert diagnosticians and therapeutists; moreover a code of ethics has gradually developed which goes far to prevent such professors from engaging in the practise of medicine, except possibly a limited consultation work, even when their experience has been such as to make them equal to it. The feeling prevails that such outside work, so different from that of his regular activities, lessens a professor's opportunities for scholarly study by its encroachment on his time and energies and detracts from the dignity, simplicity and high-mindedness of the teacher's calling. There are, of course, as the investigators of the Carnegie Foundation point out, a few men, of unusual energy or endowed with especial financial sagacity and initiative, who will easily supplement their regular incomes, no matter what profession or business they may be engaged in, but men of this kind are rare and it is probably not common to find the type especially attracted by the love of abstract studies, the quiet of the scholar's life or the particular sense of power over youth which is characteristic of the feeling of a great teacher.

That some great teachers and investigators are attracted to the non-clinical chairs despite the small material rewards and the heavy financial and social penalties pertaining to the positions, has been fully demonstrated; that some will continue so to be attracted we can be sure. Men who inordinately love gain and material advancement are not likely to work toward professorships; it is perhaps well that the professorial class is recruited elsewhere. The power of distinterested scientific creation and the passion for truth and research are seldom cerebrally compatible with the money-getting gift, the capacity to devote one's self to, and to keep the mind concentrated on, financial gain. The life of a professor is necessarily simple and frugal; his wife can make no pretense to the absurd and vulgar extravagance that Irving Bacheller facetiously and satirically describes as "keeping up with Lizzie." The career of a professor is often, however, one of profound influence and of steady happiness, of high honor and well-deserved respect, and these are rewards not likely to be regarded lightly among the more idealistic of our youth.

Still, it must frankly and anxiously be admitted that there are elements in the financial status of non-clinical professors which make us

stand in pause when we think intently on the situation. No matter how keen the love of teaching, how hearty the satisfaction in solving scientific problems, a strong man can scarcely be expected to devote himself to a life of instruction and research when the remuneration is inadequate to the real needs of himself and his family during his period of activity, and to provision for his old age.

It is highly desirable that the compensation of professors should be a little above rather than below the line of comfort for the locality in which they live. It should be, at least, large enough to furnish the necessaries and conveniences of life, without superfluity, and should not be so small as to prevent a man from saving each year a part of his receipts, even though a smaller fraction of them than Bacon recommends. The struggle to live, financial worries, inability to educate the children of the family, too great personal hardship, and the social penalties of too small an income are sure more or less to inhibit a man in his work.

This danger of insufficient income for the non-clinical professor is no bugaboo born of my fancy; there is more than one institution in which instances may easily be made of perception and not of mere ideation.

The material rewards of professorships can not, it is true, be expected to become equal to those of industrial life. It must be kept in mind, however, that the full professors in universities are the men of greatest success in their class: *if the salaries of such men fall below the line of comfort the character of the whole class is endangered and the student body and society as a whole must ultimately suffer.* Unless some method can be found for improving the financial position of the university professor it is to be feared that many men who otherwise would shed luster on scholarship will, sadly citing the well-known phrase from Horace, *virtus post nummos,* be driven away from scientific medicine to enter other pursuits. *Society ought not financially so to penalize the professorial class that the occupancy of chairs by the stronger personalities will be limited to bachelors, to childless men, to men enriched through the accidents of inheritance or marriage, or to married men who consent to doom their wives and children to the mitigated happiness which poverty affords.*

Men of some sort there will naturally be who will seek salaried positions, no matter how low the salary, and, fortunately, the love of teaching, of study and investigation will always secure a certain number of

gifted men whose passion will make them work at the thing they like under any conditions. But if the fiscal arrangements of professorships were to be made in such a way that they attracted chiefly mediocre persons to whom a salaried position spells security, the higher interests of scholarship would suffer. Attention need scarcely be directed to the progressive declension of our public schools through precisely this enforced withdrawal of their able men.

The interest in, and joy of, work, the desire of public service, the anxiety to do something well, the longing for the good opinion of one's colleagues, the obtaining of leisure to devote one's self to the finer interests of life—these must always be the great motives which lead men to become university professors. The material rewards are not, however, wholly insignificant. On psychological grounds, I have always felt that there should be some way in which all the rewards of each individual might be improved by an increase in the quality and quantity of his effort. It is by no means necessary that the increment stand in any proportional relation to the work done; men and women good enough to be professors will work honestly and loyally at the thing they want to do without any continually conscious idea of personal benefit. But there come periods in the life of each one of us when the maintenance of our higher standards is difficult, when we are tempted to be slothful or distraught; at such times, unless we are really ill and need rest or change, the more stimuli there are to exertion the better, even though some of them influence what are regarded as the less noble parts of our natures.

In salaried establishments, again, it is not always possible to avoid the defects of "institutionalism"—bureaucratic officialdom, the tyrannies of a mandarinate and oligarchic indolence; those interested in the organization of asylums for the insane have repeatedly lamented this fact.

It is easy to point out the dangers, but hard to see how to obviate them; possibly the creation of a certain number of large prizes might have the desired effect. In Germany, teaching is stimulated by the system which gives every professor a small additional fee for each student whom he attracts (*Collegiengelder*), but this system has its drawbacks and, moreover, could scarcely be applied in the United States, where as yet universities are not a chain of government institutions under federal control, and where students do not migrate. The education of

public opinion to greater social recognition of the professorial class might help; it progresses rather slowly in a country in which "success" is largely, as yet, measured by income; those who have not learned how to get money and to keep it are too often, by the unthinking, indiscriminately classified, not quite, perhaps, as pariahs, cut off socially from hope, but still as futile persons, too innocent for "achievement" in a land of opportunities!

An especially pressing factor during recent years has been the gradual rise in the cost of living without any proportionate increase in the salaries of university professors. The average price of commodities has increased by 33 per cent. to 50 per cent., but the professor who was paid $2,000 or $5,000 before this rise took place is still compelled to live on the same amount. The trustees of universities may sometimes be provided with endowments which will permit them automatically to raise or lower the amounts of professors' salaries parallel with the changes taking place in the cost of living.

The system of retiring allowances for professors, instituted by the Carnegie Foundation for the Advancement of Teaching, will undoubtedly do much to improve the economic position of the university professor. Some system which will permit, also, of insurance against death or disability preceding the age of retirement ought to be devised. The extinction of superfluous colleges with corresponding reduction in the number of professorships may lead gradually to an increase in the honoraria pertaining to the chairs that remain. The whole situation should certainly be canvassed carefully and the means discovered for enhancing in various ways the social and pecuniary rewards of professors in the non-clinical branches of our medical schools.

Position of and Tendencies in the Clinical Departments

The policies followed in the clinical departments of the better university schools are far from uniform. There is, as yet, no unanimity of opinion as to the best way to improve these departments. *All are agreed as to certain fundamental points: the desirability (1) of more thorough practical teaching and (2) of an increase in scientific productivity.* How best to move toward the practical realization of these ideals is a question.

A State of Flux

The clinical departments of the medical schools of the United States are on the eve, it would seem, of important reforms. To bring

them about, radical changes may be necessary. Faculties will, doubtless, be led to experiment in various ways; only after trials through a considerable period shall we be able to decide on the arrangements and organization suitable for general adoption in the better schools. A state of flux, already evident in the clinical departments, is, therefore, likely to continue and to become even more pronounced during the next decade.

In medicine, which is, and must always be, the department of primacy in a medical school, and also in surgery, the tendency to fill chairs by attracting able men from a distance has finally begun. It was formerly impossible on account of the absence of school-controlled hospitals. The medical faculties were compelled to accept as their clinical professors men who, developing locally, were the physicians to municipal or to privately endowed hospitals. In no other way could "clinical material" for the instruction of students be obtained. Now that universities are beginning to have their own hospitals, or to enter into arrangements with other hospitals through which their professors are assured directing places on the hospital staff, professors may be called from a distance, or be selected from the local profession, on account of their skill in diagnosis and therapy, their ability as teachers and their power as original investigators.

The Principal Clinical Chairs and the Specialties

The three principal clinical chairs in a medical school must always be those of medicine, surgery and obstetrics. A general training in each of these branches is absolutely essential in the education of every medical student.

In the specialties, there is time, in the brief period of the clinical curriculum, to teach the student only the most salient methods of diagnosis and treatment, those suited to the needs of the general practitioner. Except for brief courses in ophthalmology, psychiatry and, possibly, pediatrics, it is doubtful whether, in the time at present allotted to clinical instruction, it is justifiable to make obligatory any training in the clinical specialties beyond that which can be given in the departments of medicine, surgery and obstetrics. There are three reasons for the view here advanced. In the first place, medical schools are as yet, in this country, devoid of the endowments necessary for the equipping and manning of university departments in the specialties like

gynecology, genito-urinary diseases, orthopedics, neurology, ear, nose and throat, dermatology, gastro-enterology, etc. In the second place, courses given to undergraduate students in such departments, could they be established, would have to be rigidly restricted to essentials if each subject were to occupy, in the curriculum, its true position of relative value to the student. A specialist, naturally and properly impressed with the importance of his own subject, tends to enlarge on it and to inflate it out of all proportion to its legitimate position in the undergraduate medical curriculum. The right place for extended courses in the specialties is in the postgraduate medical school in which men equip themselves for special practise. And, in the third place, it is important that teachers in the general departments of medicine and surgery be able to diagnose all ordinary conditions and to treat the simpler and commoner affections, no matter to what special branch they belong, just as the family practitioner has to do. What a bad impression it must make on a student in the medical wards if his professor of medicine, when a patient complained of cough or of hoarseness, was unable to make a larynoscopic examination, but had to refer the patient to the specialist in the "throat and chest" clinic; or if, when the patient had indigestion, he were referred to the "stomach clinic," or in the case of palpitation to the "heart clinic"! And how discouraging it would be also to the student in the surgical wards if his professor of surgery felt himself incapable of examining the prostate, of recognizing a flat foot, of detecting the presence of a pus tube or of diagnosticating a simple eczema. The continual reference of such cases to other departments without at least preliminary study by the teachers of general medicine and surgery would imply such a disintegration of medical thought as to have a very bad influence on the students. The tendency would be for them to grow accustomed to the idea that it was not necessary for them to examine every patient thoroughly or to treat him. "If the professor of medicine or surgery in a great medical school is unable to differentiate the simpler and more common conditions in the special branches, how can we be expected to do so when we go out into practise for ourselves?" is a question these students would ask themselves.

The picture of medical practise as seen in the six great branches—medicine, surgery, obstetrics, ophthalmology, psychiatry and pediatrics—is already so intricate that it would be unfortunate if students in the

medical schools were compelled still further to complicate it. Moreover, a medical clinic in which the larynx was not inspected, the eye-grounds not looked at, the stomach not examined, the heart not auscultated, or in which electric and various laboratory examinations were not made, would be a caricature of a medical clinic. Each assistant in our great clinics, though especially skilled in the technic of his own branch, should command all the ordinary methods of examination which the general practitioner may be expected to employ. The student should be impressed with the fact that there is no "witchcraft" about the technic of these methods, that it can be acquired by practise and routine and that it must be so acquired. Billroth long ago called attention to these points and urged that, if all the special methods of investigation were shoved out of the major clinics into special courses, not an integral part of them, and, especially, if, in such special courses, the technical side were so expanded as to become disproportionate, sight would be lost of the relative significance of each specialty in the study of the body as a whole and the students in the medical school, through the extreme disintegration and the lack of cohesion, would become completely discouraged.

For the postgraduate work of the university medical school, the special clinics are highly desirable. In them the special subjects ought to be advanced by original investigation; there, too, physicians should be able to prepare themselves for special practise. Where the material is rich, and especially when the man directing a special clinic is intellectually able and possesses creative power, a reputation could soon be gained which would attract postgraduate students from different parts of the civilized world; such a special clinic would lend brilliancy and prestige to the university which provided for it. But, while arranging liberally for scientific and investigative work in all the general and special clinics, great care should be taken to see that this is not done at the cost of the undergraduate instruction.

The Hospitals of the Medical Schools and Their Management

The most pressing need in the clinical departments of the medical schools of the United States, at present, is that of school-controlled hospitals in which the students may actively participate in the work of diagnosis and treatment and, under skilled direction, be held responsible therefor. *In the hospitals, the conditions should permit of an*

adequate organization for the three great functions of a university clinic —practise, teaching and research. These hospitals should be large enough to supply sufficient clinical material in internal medicine, surgery, obstetrics and in the principal specialties. The organization should ensure a large degree of departmental autonomy while providing for proper correlation of the activities of all the clinics.

It is only here and there in the United States that one finds belonging to a medical school (1) a hospital of sufficient size, equipped with teaching and working quarters, with wards situated in immediate contact with commodious clinical laboratories, (2) an organization according to which the professors of the clinical departments of the medical faculty are also the principal physicians and surgeons on the hospital staff, the whole control of the individual departments being in the hands of the respective professors. Until medical faculties obtain by endowment or agreement facilities of this sort, the clinical sciences must remain backward in their development.

There is, probably, not a single institution in the United States which has, as yet, a wholly satisfactory arrangement between the medical school and the hospital in which the clinical work is done. Even in some of the institutions pointed to as paradigms of an ideal relationship the conditions are, in reality, far from ideal. Unless the medical school and the hospital are actually integral parts of a single corporation it is hard to devise an organization which will prevent friction; for, in the present undermanned clinics, the hospital, on the one hand, is often found maintaining that the staff is paying too much attention to instruction and to research, to students and to laboratories, and not enough to the interests of the patients themselves, while the medical school is constantly urging that the routine work of the care of patients in the hospital is not university work, that those devoting themselves to it are not worthy of university recognition, or that they are too much interested in caring for the patients and not sufficiently devoted to teaching and the solving of those problems in diagnosis and therapy which the study of the patients should suggest. Where the finances of the hospital are kept separate from the finances of the medical school there are often disputes as to the portion of the expense in the clinic to be borne by the hospital on one side and by the medical school on the other, and even when, after conference, a theoretically satisfactory understanding as to the division of expense has been

arrived at, one finds, in actual experience, a persistence of the friction. In my opinion this vexatious state owes its origin (1) to the separate developments in this country of the hospitals and the medical schools, (2) to the imperfect fusions which have come later on, leaving authority still somewhat divided, (3) to the immense amount of work to be done and the insufficient number of people to do it, and (4) especially, to a misunderstanding both by hospital officials and by university authorities of the value and dignity of the different portions of the work which must be carried on in the clinics. In reality, the interests of the hospital and of the medical school are one when the functions of the clinics are properly understood, organized and administered; there should be no more quarrel between hospital and medical school than between unselfishness and the higher selfishness. But as long as there is a division of responsibility and control, ideal conditions in the clinic will rarely, if ever, be reached.

Another serious defect in the hospitals as they are now lies in their management as general hospitals under an executive head, rather than as separate, largely autonomous clinics, the activities of which are correlated by a committee made up of representatives of the individual clinics in association with a general executive head. Until we have, as in the German hospitals and medical schools, (1) a medical clinic, (2) a surgical clinic, (3) an obstetrical clinic or a woman's clinic, and (4) the various special clinics—each organized as a separate entity, with its own staff, preferably with its own buildings, certainly with its own budget, with control vested in the department itself—the conditions under which work is done will continue to be unsatisfactory. Unless the department of surgery, for example, can admit and discharge patients at will, can decide on the kind of work it will do, can buy instruments, books, etc., whenever needed as long as the budget of the clinic is not exceeded, surgery and surgical investigation will be hampered. When these matters, for all the clinics, lie within the province of an extra-departmental authority there are apt to be unnecessary delays, arbitrary decisions and other obstructive measures which are irritating and inhibiting to work.

These difficulties are pointed out without any intention of unfairly criticizing executive officers in our large general hospitals. Among hospital superintendents there are many men of unusual executive ability and of high ideals; they have often cooperated harmoniously

with those who have the interests of the medical school at heart. My comments refer merely to the faults inherent in a system; the positions, as at present constituted, certainly have in them factors which do not make for the best interests either of hospital or of medical school. One of the problems to be worked out, then, in our university hospitals, consists in articulating satisfactorily the general administrative work of the institution with the special administrative work of the individual clinics; in other words, we must find out how those who examine patients and treat them, those who instruct students and those who make original investigations, can be relieved of general administrative difficulties, on the one hand, and favored in their special departmental functions, on the other.

Of course, it should be admitted frankly that, in the present system, general superintendents of hospitals often find departmental professors difficult. Not every professor of medicine or surgery is a good business man or has administrative skill; indeed it is not uncommon to find men strong as investigators, teachers or practitioners, but somewhat lacking in business sagacity and executive ability; occasionally when gathered, grumbling and querulous, in a superintendent's office, they convert it into a veritable cave of Adullam! In particular instances provision might be made to free a professor as much as possible from administrative work. It could be easily carried on for him by another member of the department, or by a chief clerk who might be a non-medical man. The ultimate solution of this difficult problem may lie in the appointment of a salaried executive clerk in each of the clinical departments to look after administrative matters, the work of all such officers to be supervised and correlated by a general business superintendent who would be responsible to the medical board of the hospital.

Departments of Internal Medicine

The functions of each of the clinical departments are manifold and complex. Let me refer to some of the activities of the branch about which I know most; namely, internal medicine. If one attempt to resolve the functional complexity of that branch into its component aspects one can distinguish, at once, at least four principal parts:

1. The *practise of medicine* in the public and private wards and in the out-patient department and the laboratories thereto pertaining, by which I mean the actual diagnosis and treatment of disease in the patients who enter the clinic.

2. The *teaching* in the wards, in the dispensaries and in the laboratories of (*a*) undergraduate medical students; (*b*) assistants and associates; (*c*) physicians taking postgraduate courses in the department.

3. The prosecution, by professors, assistants and postgraduate students, of *original inquiries* in internal medicine, the search for new methods of diagnosing and treating disease, the attempt to advance our knowledge of the subject beyond its present boundaries.

4. The *administrative duties,* including the admission, transfer and discharge of patients, interviews and correspondence with physicians who bring patients, and with the relatives and friends of the sick, the relations of the clinic to housekeeping and nursing, the maintenance of records and statistics, the arrangements for publications, the superintendence of budgets and expenditures, the making of appointments and promotions, the attendance on departmental and inter-departmental conferences, the formulation of curricula, the organization, equipment and running of the several clinical laboratories, the library, and the museum, the integration of departmental activities, the development of an *esprit de corps,* etc.

The Practise of Medicine in the Clinic

Turning now to a little closer examination of the work of the medical clinic of a modern school and hospital it will be found that the practise of medicine in the clinic itself is, separately considered, no small task. In order that the teachers and investigators in the clinic may be sure of getting what they need, or prefer, in their work, a large number of cases from which to select must be admitted to the hospital. The larger the clinical material available the better. The time may come when, in addition to the general reception wards of the stationary clinic, there will be special wards to which may be transferred the cases most suitable for teaching, on the one hand, and for investigation on the other. The larger reservoir for the reception of the cases previous to selection will always be necessary, for in the first place, until a patient has been fairly well studied, one can not be sure how valuable he may be for illustration in teaching or for the suggestion of problems for original scientific investigation; in the second place, every great hospital must, on humanitarian grounds, take in many cases which, at the time, may be of relatively little educational or scientific interest.

A large department for out-patients, a so-called "policlinic" or "ambulatorium," is also necessary for three reasons: first, on humanitarian grounds, to provide treatment for the poor who, though not well, are not so sick as to require admission to the wards of the hospital; again, as a feeder to the stationary clinic, to which can be sent the sicker patients, those exemplifying unusually well the pathological states under consideration at the time in the educational work in the wards, and those presenting obscure conditions, necessitating for diagnosis more elaborate studies than are feasible in the policlinic; and finally, for teaching purposes in the policlinic itself, for here material of a special kind becomes available for the teaching of students, including not only slightly ill patients suitable for the practical courses in physical diagnosis and other propædeutic studies, but also precisely the types of minor ailments which the young physician is most likely to meet when he starts out in practise. The ills of the ambulatory patients, though sometimes permitting continuance of occupation, require regular supervision. Chronic diseases of the heart and blood-vessels, of the kidneys, of the liver and lungs, perhaps prevail. Functional nervous cases are also frequently seen. The student has the opportunity of inquiring into the personal history and social relationships of such patients, to investigate the bearing of obscure organic disease on psychoneurotic states and to see in how far they may be influenced by psychotherapeutic and other remedial measures. In connection with the social service department, the personal relations and experiences of these patients can be investigated and, sometimes, disentangled. Organic nervous cases (tabes, multiple sclerosis, etc.) can also be studied here to advantage, since but few hospitals have as yet provided special neurological wards, and where they have been provided they can take care of but a fraction of the material which offers.

In addition to the public wards and the policlinic, most university hospitals have, and all should have, private rooms in which pay patients may be received. In them well-to-do people may avail themselves of the services of the men of unusual skill and reputation on the hospital staff. The occupants of such rooms can usually afford to travel long distances in the hope of superior study or treatment. Hospital workers with national or international reputation will, therefore, attract the interesting clinical puzzles from widely distant points and thus extend the clinical material of the hospital.

Among the well-to-do there are sometimes individuals of superior intelligence, types of men and women rarely to be met with in the public wards of the hospital. The stimulus to study a disease in, and to make a discovery that will restore the health and activity of the body of, a person of superior intelligence (*e. g.*, an illustrious artist, a scientific discoverer, a captain of industry, a leader of labor) will be somewhat greater than the stimulus yielded by a similar malady affecting a person with mediocre, or distinctly inferior, brain in either the private or the charity ward. The direct benefit to society means more in the one case than in the other. The anticipated contributions to medical knowledge in the two instances might be of equal value as far as future use by the profession is concerned, but the finer immediate need makes a special appeal. This may account for the number of important therapeutic measures which owe their invention or discovery to problem-solving suggested by private patients. Further, the endowment of medical research by private individuals is encouraged by the acquaintanceship with medical needs that the private wards foster. Finally, the private patients treated do much to support the reputation of the hospital and its staff and thus affect favorably the standing of the medical school and its graduates.[4]

The responsibilities of diagnosis and treatment of this vast collection of clinical material, public and private, stationary and ambulatory, are a grave burden which the clinical staff must bear. The mere technical procedures of the thorough examinations made and of the therapeutic measures carried out involve a large expenditure of time and energy. Students, house-officers, and senior assistants may well bear the brunt of this work, but, in addition, an associate professor, or, in the larger institutions, preferably a full professor, may well devote the major part of his time and energies to it, leaving most of the teaching and

[4] Certain precautions ought always to be taken to prevent abuses; for instance, the private wards should never be so greatly developed that the public wards and the out-patient departments become a mere appanage of a large private sanitarium. *Especial care should be taken that the teachers and investigators in the clinic do not become overburdened with private patients.* It may be necessary to regulate the amount and distribution among members of the staff, of this kind of work, and to exercise some supervision over the fees charged. The practise in such wards should exemplify the highest ethical standards of the profession. The hospital should never enter into unfair competition with physicians and surgeons outside; the admission of patients to the private wards of hospitals with payment only for room and board, and without the payment of fair fees for professional services rendered, is unjust to the practising profession.

experimental investigation to others. The philanthropic work of the hospital, as well as the reputation of the institution among physicians and among the laity, depends on the thoroughness and courtesy with which this work is done. Moreover, the teaching and investigative functions of the clinic can be properly developed by those who are devoted especially to them only after this fundamental function of diagnosis and treatment has been fully provided for. The mere administrative side of this part of the work is complex and time-consuming. The admission and discharge of patients, the maintenance of records, the arrangements for special examinations by workers in neighboring clinics, the interviews and correspondence with the patients' friends and relatives and with their physicians—all require time, thought and a special kind of skilled executive ability. The patients are very different from the guinea-pigs and the rabbits of the laboratories, and can not be treated or operated on in the same way. Nor can you dismiss a patient's relatives with that lack of ceremony which is sufficient in a guinea-pig's case; they must be talked to, and written to, occasionally. Laboratory men discussing clinical reforms sometimes seem to forget this. Even the best executive officer can not wholly escape from the matters referred to, though as the organization becomes perfected, the chief supervisor can turn over much to junior men.

The application of the principles of "scientific management" to the details of the work in the clinic promises improvements. If every element in the work of the clinic, from out-patient department to private ward, were subjected to searching inquiry, much waste of time, waste of energy and waste of material could be eliminated. At present there is little uniformity in the technic of clinical examinations and the personal element enters far too greatly. *It is highly desirable that experts shall decide on the one best method to use in each instance,* that these best methods shall be adopted as standards, the efficiency of all the workers being gradually brought up to these standards by careful instruction, and the organization made such that the plans will be self-perpetuating. This task is far easier to talk about than to accomplish, but it should be undertaken.[5] Modern commerce is developing systems of efficiency beside which the management of clinics cuts a sorry figure. We need a "commercialization of medicine" in the good sense and

[5] Taylor, F. W., "Scientific Management," New York, 1911; Gantt, H. L., *System*, February, 1911; Cooke, M. L., Bulletin of Carnegie Foundation, 1910.

must see to it that the term "medicalization of business" is not coined as a byword of reproach!

The Teaching of Internal Medicine

In the performance of the second great function of a medical clinic, that of teaching in the wards, in the dispensaries and in the clinical laboratories, a fairly large staff, a well-thought-out plan and the devotion of much time and energy are essential. *The amount of teaching in a department of internal medicine is, and should be, greater than in any other department of a medical school.* It makes up a large proportion of all the work of the third and fourth years, and from now on is likely to include also a part of that of the second year of the undergraduate course.

Since the graded medical course was inaugurated by Northwestern University many years ago, American clinicians have gradually arranged a sequence of studies in the medical clinic which permits of a methodical advance in the instruction. The student from the beginning of his clinical studies is made regularly and purposefully to climb a ladder which connects the fundamental training of the non-clinical departments with the professional occupation which he is to take up after graduation. Instead of the didactic and merely demonstrative teaching which formerly prevailed, a thorough practical training in clinical work is now required. After a general introduction to clinical methods and aims at the end of his second year, the student is, in his third year, instructed in the principles and art of physical diagnosis (inspection, palpation, percussion and auscultation), and he is taught, in the systematic practical course given in the clinical laboratory, how to make examinations of the sputum, urine, stomach contents, feces, blood and the various body fluids. In the third year, too, he learns the method of taking clinical histories and of keeping protocols, hears a certain number of general didactic lectures, attends amphitheater clinics which stimulate his interest, studies a good text-book, and is tested as to his progress by carefully conducted recitations. In the latter part of the third year he may profitably engage in the actual history taking, physical examination and therapy of ambulatory patients in the policlinic.

Important as this propædeutic work is, it is overshadowed in benefits conferred by the medical work of the fourth year, when the under-

graduate student is required actually to do an important part of the work in the stationary clinic. Here, as a clinical clerk, he has a certain number of beds assigned to him and is permitted to regard the patients occupying them as his patients, for whose study and care he is personally, in large degree, responsible. These clinical clerkships, the glory of the teaching of medicine in Edinburgh and London, introduced into this country by Osler, and now meeting with general adoption, offer the best opportunity conceivable for students to acquaint themselves with the technic of the art of internal medicine. The task of giving much responsibility to students while keeping strict control and exercising the sharpest and most thorough supervision over them, is not an easy one, but it is being satisfactorily worked out in our better clinics. Nothing could be more disastrous to patients or students than to give responsibility without control and supervision; granted these, patients, students and hospital staff alike profit. Since on entering the stationary clinic the students are prepared to make more or less accurate laboratory and physical examinations, a higher order of routine can be maintained in the medical wards with their help than would be possible with the staff alone. An auxiliary body of workers, to which the simpler tasks can be deputed, leaves the staff at greater liberty to devote itself to the more difficult technical procedures and to advanced studies which otherwise could have only a limited application or would have to be entirely dispensed with.

Students and staff thus work together in the medical clinic as a harmonious group. The cases under examination are compared with similar cases in the literature. The spirit of thorough investigation is cultivated; each worker is encouraged to ask himself how the particular cases immediately in his care can be more completely analyzed and what problems they present suggestive of experimental or statistical inquiry. The treatment instituted can be carefully observed, for the work is concentrated, the students practically living in the medical wards for several months at a time; any results attributable to therapy can be observed and recorded. If a patient gets well the students are urged to follow up his subsequent history; if he dies they attend the autopsy in the pathologic laboratory and compare the anatomic findings with the clinical inferences which have been drawn during life.

In all this medical work, in both the third and fourth years, it is essential that the students be divided into small groups and that each

group be directly supervised by some member of the clinical staff. The immediate hourly supervision will, of necessity, devolve on the younger men on the staff, but a heavy burden also falls on the senior members of the department who must, themselves, keep in intimate touch with the students and junior staff—controlling, criticizing, reviewing, suggesting, encouraging. At least one full professor and two associate professors, whose function shall be predominantly teaching, are needed to plan and to conduct this work; in larger clinics it would be of advantage to have two full professors assigned to this function. In some of the schools, the teaching professors will also be the authors and revisers of text-books of medical practise.

One rewarding part of the work of a teaching professor in such a department is the instruction given to the junior men on the staff—the assistants, instructors and associates; not only can a professor through them extend his influence over the students, but he will be able to discover in his staff those whose native ability and inclinations give promise of teaching power, and by developing them provide a stock, whence the successors to those now teaching may later be drawn.

The clinic should also receive, as far as its facilities will permit, physicians who desire to take postgraduate courses in internal medicine. These physicians fall, roughly, into two groups; first, graduates of several years' standing (or recent graduates of inferior colleges), who, like undergraduate students, need a thorough training in the fundamental methods and principles of the clinic, and, second, advanced men, who, well-trained in the fundamentals, are ready to take up higher work in internal medicine and to specialize in it, some of them along the lines of practise, others along the lines of teaching, and still others along the lines of original inquiry. In a good organization, these advanced men would, according to their special needs, be distributed among the workers in the department, some being sent to the men chiefly engaged in the care of the patients, others to the men especially occupied in teaching, and a select few to the men wholly absorbed in experimental research.

Discovery in Internal Medicine

The third great function of the clinic of internal medicine is that of original investigation. It is a fortunate feature of clinical work, one doubtless that has had much to do with that steady progress in knowledge which throughout time the clinics have made, that even the routine

work in a clinic is largely work of research. Each new patient is a problem for investigation; the clinician applies the methods he has learned and tries to solve it. The essentially inquisitive nature of the every-day work of the clinician has to be personally known to be fully appreciated. In addition to the ordinary routine of clinical work, physicians are constantly trying out new methods of examination and treatment that have been devised and recommended; this work, carefully done, the observations being accurately recorded and analyzed, affords material for statistical inquiry, the results of which are often of high importance to the profession. When a new method of determining clinically the size of the heart has been proposed, or an early diagnostic test for typhoid fever or for syphilis or for carcinoma of the stomach suggested, long experiential proving in the clinics must decide as to its value before it is accepted for general routine. A great clinic, scientifically controlled, can thus continually advance knowledge and help on the practical work of the profession.

It is, naturally, not the function of the clinic to do work in abstract anatomy, physiology or pathology. The aim and purpose of the clinic is, on the contrary, to continue the applications already made, and to make new applications, of the facts of anatamy, physiology, pathology, chemistry, etc., to the solution of problems in diagnosis and therapy suggested by patients who come to the clinic for help. Unless clinical men fully realize this point, unless they have a full consciousness of precisely what the clinic is for, they may be led astray by those who feel that "applied science" is very different from "science."[8] Clinicians are sure, now and again, to make certain contributions to pure physiology or pathology when trying to solve their own problems in diagnosis and therapy. They will be glad when their work so contributes, but this should not be the main aim and purpose of that work; as soon as a man in the clinic finds it to be so, it is time that he left the clinic and transplanted himself to a laboratory of physiology or pathology. Clinicians

[8] A mathematician sometimes feels that his work is more scientific than the work of the chemist or physicist; the latter, in turn, is too prone to regard the biologist or physiologist as an unfortunate worker in applied science, and to speak with some contempt of the efforts with complex and mixed substances made by the biologic chemist, or the immunologist; the physiologist and the pathologist again only too often fail to attribute scientific value to the efforts at application of the facts of their subjects made by clinicians. There will always be, I fear, this misunderstanding of the applied sciences by the sciences basal to them.

must jealously guard opinion in this matter; otherwise their sciences can not satisfactorily progress.

In the United States, there has of recent years developed much sympathy with the German ideal, which requires not only that every university professor shall know the results of the most recent researches in his subject, but that he himself shall also be an investigator and forwarder of knowledge in the branch of science which he teaches. A modern department of internal medicine, according to this ideal, will be not only a place for transmitting what is known to medical students, but also a place in which the unknown is actively explored, teachers and pupils, though engaged in the routine work of the clinic, living also in an atmosphere of original research. Students profit when they observe knowledge in its growth; to some extent at least they should control the facts which they learn from books and from teachers by first-hand examination; they should be encouraged to apply the methods of modern scientific investigation to the objects which they, themselves, observe. *Thus introduced to the spirit and method of scientific inquiry, the students are protected from the dogmatism which so often accompanies mere traditional teaching.* They see for themselves the weak spots in internal medicine and begin to think of methods of attacking them.

In Germany, the ideal of research has been so glorified that some of the professors, even in the clinical branches, have devoted themselves largely to it with gratifying results in contributions to knowledge. In internal medicine, however, in Germany, the undergraduate teaching has been to a certain extent sacrificed for the sake of research, the system of clinical clerkships not yet having been instituted.

In the United States, the emphasis has been laid rather on the teaching of students; clinical research has been, until recently, less cultivated. This may explain the higher state of clinical science in Germany, on the one hand, and the better physicians trained by the good schools in the United States on the other. Germany ought to reorganize its clinical teaching so as to make better doctors;[†] in the United States we should set about increasing the scientific productivity of the clinics. In both countries the defects are becoming clearer in the academic consciousness; the evils persist less from lack of recognition

[†] An effort in this direction, recently made in Germany, may be seen in the "hospital year" now required at the end of the medical course there. It appears to correspond to our hospital internship, made compulsory.

of their existence than because money and men for the realization of ideals are not yet available.

In order that clinical research may make more rapid advance, and the sciences of diagnosis and therapy be furthered, *the experimental method should be more extensively employed.* Owing to the peculiar conditions which have prevailed in the clinics up to now, only a few men, either in Germany or in the United States, have had the time, interest, training and independent income which have permitted them to do extensive original work by experimental methods in laboratories directly attached to the clinics. Recently, however, more of this work has been done. It has been very welcome, and the time has come when it would seem desirable to make this kind of research more systematic and purposeful, less casual and accidental. Each medical clinic, in addition to its laboratory in which undergraduate students are taught, and in addition to the small laboratories connected with the wards, in which routine microscopic, bacteriologic, chemical, radiographic and electric examinations are made on patients or on materials derived from the wards, should have three or four special clinical laboratories, expressly designed for scientific investigative work, for solving problems in diagnosis and therapy which contact with the patients in the clinic suggests.[8] In the biochemical laboratory of the medical clinic the methods of modern chemistry may be applied to the solution of clinical problems, especially those of metabolism. In the biologic (serologic) laboratory the problems of infection, immunity, and experimental therapy may be approached. The physiologic division of the laboratory may carry on experiments bearing on cardiovascular, renal and other diseases. If a fourth, psychopathologic, laboratory be available, all the better. In these laboratories for medical research there should be medical investigators, especially trained in the so-called pure sciences of physics, chemistry and biology, who will devote themselves to the application of the methods and principles of these sciences to the solution of the special problems by which workers in the clinic are confronted. *These men should be paid liberally enough to permit them to devote their whole time and energies to research,* the rewards of their positions being regularly enhanced during their productive years.

It would be short-sighted of internal medicine to neglect these powerful engines of exploration and enrichment. The other depart-

[8] "The Organization of the Laboratories in the Medical Clinic of the Johns Hopkins Hospital," *Johns Hopkins Hospital Bulletin*, 1907, XVIII., 193–198.

ments of applied science have set us the example. Technology has demonstrated the efficacy of paid research work for the promotion of the industrial arts (metallurgy, brewing, electrical engineering, sugar refining, food preservation, the manufacture of arms and ammunition, etc.). *It would be a distinct advantage if at least one liberally endowed full professorship were provided in the clinic of internal medicine, in which a man of original ideas, thoroughly trained in methods of research, could, undistracted by administrative work, by private or hospital practise, or by undergraduate teaching, devote his whole time and energies to it.* A mind full of heuristic hypotheses, a curiosity which compels the accurate testing of them, a body inured to intense and confining work, the privilege of continuous, uninterrupted application to laboratory studies, a guarantee of financial independence, liberal support in the form of equipment, facilities for experimentation, assistants and mechanical aids, and the entire sympathy and cooperation of those who attend to the major part of the practise and the teaching of undergraduates in the clinic would be necessary to make the venture fruitful. Assume the existence of such conditions in our departments of internal medicine, and find for the research professorships men of the type of Louis Pasteur, Robert Koch, Paul Ehrlich or Simon Flexner—what dare we not expect in the way of extension of diagnostic recognitions and of means of cure?

And what an opportunity such an arrangement would offer for post-graduate study! A few advanced scholars, desiring to widen the science of internal medicine, could cooperate with such a research-professor in the "master work-shop," and, according to their ability, experience the wonderful joy of creative work. One who has once been permitted so to participate will never forget it. Many regard this last and highest phase of personal education as the acme of their inner experience.[9]

Despite the unfavorable conditions now existing in the clinical departments, strong men have been attracted to them. All things considered, patients are being very well cared for, good physicians are being trained, a very fair amount of original work has been produced. The bibliographic output, including text-books, handbooks and publications of original research, compares favorably with that of any one of the laboratory subjects. As to foreign recognition, it has been fully as great for the clinical chairs, if not greater, than for the non-clinical depart-

[9] Cf. Ostwald, W., *Die Umschau*, January, 1911.

ments. Many foreign clinicians have visited American clinics and most of the foreign students who have come to this country to work have entered clinical rather than non-clinical departments. Several clinical text-books have been and are being translated into other languages.

The Movements Toward Reform

The tedium of this long description of the functions of a medical clinic would scarcely be justifiable were it not for my desire clearly to establish a fact of importance, namely, the growth of the functions of the clinic to a size and complexity no longer compatible with the form of its present organization.

Hitherto there has been only one professor at the head of a clinical branch, and he has been supposed to engage in, care for and control all these varying activities and, in addition, to make the major part of his income in practise outside the hospital, only a few institutions, thus far, having been able to pay salaries which would defray even a portion of the cost of the clinician's living. Surely the superhuman has been expected!

We have now briefly to consider how the clinics can best be organized to meet modern requirements, and I shall again refer chiefly to the medical clinic, assuming that a plan which will suit its exigencies may, with certain modifications, be applicable to the other clinics.

The first step toward improvement will consist in the spread of the conception of the clinic as elaborated above, in *the recognition of the need of a functional division of labor in the clinic* corresponding to the growth and enrichment of its varied activities and to the different types and qualities of men attracted to the tasks and problems of clinical fields. Differentiation is perhaps the most characteristic feature of progress of mind; once we have, through an intellectual process, resolved the complexity of the clinic into its main divisions, it would be folly to ignore the sense of achieved distinctions, and real stupidity to lose what we have gained, by again confusing things which right reason has put asunder. In manning the clinic of internal medicine, we should, therefore, keep in mind the constituent functions, choose enough men and assign them to duties accordingly.

Whether to make (1) vertical sections through the clinic with especial reference to the three great functions of (*a*) practise, (*b*) teaching and (*c*) research throughout the hospital, the undergraduate medical school and the postgraduate work, or (2) transverse sections

at the levels of (*a*) the routine hospital work, (*b*) the undergraduate instruction and (*c*) the postgraduate instruction, are questions for the wise to decide. Though I lean to the latter method, it is surprising, on consideration, how similar the division of labor would work out, whichever way the sections were cut. Those who devote themselves chiefly to the care of patients in the clinic need not be men who do a great deal of teaching and investigation. Those who are mainly responsible for the teaching in the undergraduate school should not be burdened with the care of too many patients and would of necessity have to limit the time given to investigation. Those, in turn, who give their time and energies almost wholly to research should be protected, as far as possible, from the teaching of undergraduate medicine and from the cares of practise and administration.

Here, then, we have in mind a clean-cut conception of an ideal of organization toward which we may strive. What is now a single professorship could be replaced by *a cooperative committee of professors* in charge of a large and differential staff. In small and less liberally endowed colleges it may be necessary to be content with one professor and a group of associate professors or associates. In the larger colleges with greater funds a group of full professors should be found and supported. The so-called "headship of the department" could be matter of election, or rotation, or there might even be "government by commission" within the department. In any case provision should be made for regular conferences in which the leaders of the work should be intimately and harmoniously associated. This maintenance of the *unity of the clinic* seems to me better than the disintegration toward which we are at present tending (establishment of separate research institutes; creation of chairs of experimental medicine, experimental pathology and experimental therapy), though the creation of several separate departments would be better than a continuance of the single department in its present overworked and undermanned state.

In an address delivered some years ago, entitled "Medicine and the Universities,"[10] I made some suggestions regarding the clinical branches; even then, though I was engaged entirely in laboratory work, it seemed to me that the clinics were undermanned and that the work in them was insufficiently differentiated. In that address it was intimated that the time might come when, in the clinical branches, we

[10] *American Medicine*, Philadelphia, 1904. [Reprinted in this volume, *q. v.*]

should have at least two kinds of professors: (1) Professors on a so-called "university basis," paid salaries large enough to enable them to devote their whole time and energy to teaching and investigation, without engaging in private practise; and (2) professors who give a part of their time to the care of patients in the hospital, to teaching, and to investigation, and who, though paid smaller salaries, obtain their income chiefly from the fees of private patients, preferably from consultative or operative work. The ideas there set forth, in the main, still hold good, though it is doubtful if they can be applied in precisely the manner I then suggested. Though the clinic then seemed complex, I know, to-day, even more of its intricacies and difficulties, and the problem looks less simple in solution at close range than it did at a distance.

Were a new medical school to be started, with liberal endowment, it would be an interesting experiment to try an organization in which a functional division of labor, such as I have outlined, is provided for and in which some of the professors, especially those devoting themselves almost entirely to research, will be paid sufficient salaries to permit them to escape from practise.

It has hitherto been taken for granted that the professor of medicine in the medical school would engage in medical practise and that the professor of surgery would have his private patients, each reaping the financial rewards attending on such work. The prominence of such men and their unusual training and opportunities have made them, as a rule, much-sought consultants rather than general practitioners, though many of them naturally began with general private practise in their respective branches, and, as their work grew, limited it, later, to consultative or operative practise. Only rarely have the occupants of clinical chairs been paid living salaries. As a rule the clinical teachers have had to depend for their living on the fees of private patients. As a man's reputation grows with the public, the demand on him from outside becomes more and more pressing and difficult to withstand and is likely to encroach ever more on the time which the clinic itself requires. Though some men of strong character and unusual sense of order may systematically apportion their time so as to protect themselves and the clinic from a clamoring public, not all men are able to do so, and our great medical schools show more than one example of professors who, in the earlier part of their incumbency, have devoted a large part of their time and energy to the hospital and medical school and, later on, have become so involved in practise as to make them less

valuable for teaching and investigation. Even when men are strong enough and systematic enough to maintain a fixed relationship among their several activities, hospital work, teaching, research and consultative practise, the question has been raised whether the increased material rewards enjoyed by such men may not be harmful to the men themselves and to the clinics in which they work. This objection, urged especially by those who favor a general movement toward socialism, the substitution of salaried public service for private enterprise, is one which should be carefully considered by medical educators. The whole subject is now being much discussed and the fact that, thus far, no unanimity of opinion has been arrived at makes it probable that a good deal is to be said on both sides.

In our reorganized medical schools it does not seem to me probable that it will be desirable soon, if ever, to have all the men of the faculty composed of non-practitioners. It would seem distinctly advantageous to have at least some of the teachers of undergraduates and some of the men who care for the patients in the hospital also engaged in private practise, at least in consultative or in operative work.

In all attempts at reconstruction our efforts should, at first, be tentative. It would be a mistake to start with any cut and finished garment that we should ask the medical schools immediately to don. Though having the essentials of our ideals in mind, the proper method of attaining to them and the proper expedients would have to be slowly established. At an early stage of reform, anything like extreme measures should be sedulously avoided. In making profound changes the process of transition must not be flatly ignored. The ideal clinic can scarcely be attained by proclamation. The obstacles in the way of progress must be carefully measured and we must keep in mind the cardinal fact that "all true development and progress are out of and because of what has gone before."

It is among the inconveniences attending all important reforms that the disciple overstates the teacher, exaggerates some features of his doctrine and is oblivious to, or insufficiently appreciative of, others. There is always danger of confusing novelty with originality and alteration with progress. Because we desire research is no reason for doing away with teaching and practise in the clinic. Nor would, in my opinion, the limitation of every professor in a university to the material rewards of an insufficiently salaried position prove a panacea or a magic "open sesame" to the medical millennium.

Some enthusiasts urge the summary dismissal of the clinical professors now active and the substitution of non-practising men. Even if this were advantageous for all the chairs, as some erroneously think, it would be difficult to apply such an organization abruptly in the schools already established. Men who now occupy the clinical chairs and who have of necessity ordered their lives for the double function of professorship, on the one hand, and of consultative or operative work on the other, have become so involved in obligations that they could not suddenly change to a salaried basis without great hardship to themselves and their families, and loud complaints from the public. The cost of living of one who has to make the larger part of his income by consultative work in internal medicine, or operative work in surgery, is of necessity wholly other than that of a professor who limits his work entirely to the university and lives on a salary. The former has to have a different kind of house, in a different part of the city; rapid and easy transit is necessary for him if he is to husband his time and his energy, and, in general, he is involved in a scale of expenditure correspondent to the life he leads. If it were demanded that these men should abruptly become whole-time professors, and give up the remuneration they now receive from private patients, it would mean the elimination of the majority of them from the medical faculties and their replacement by younger and less experienced clinicians. Now, the majority of our leading clinical men to-day would, I believe, of their own free will give up their chairs to so-called "whole-time" men and be content to withdraw or to be part-time professors if large endowments for the purpose were at hand, if a great reform in the clinical subjects could thus be made and a sufficient number of adequately trained and intellectually able men could be secured to take their places. But it may well be doubted whether a sufficient number of entirely suitable men are now available for the purpose. Hitherto there have been no endowed clinical professorships, and should they be established, men would have to be trained especially for them. For this reason alone, the change could not be promptly brought about; and besides, any extreme and harsh measure like compulsory expropriation of the chairs might do damage, inasmuch as anything that makes the tenure of university professorships insecure injures the universities.

It must be kept definitely in mind that the majority of the present incumbents of clinical chairs hold them in good faith; that they do their best in the conditions that now exist; that they, as much as any

group, desire to see the clinical subjects advanced, to have the patients better cared for, to improve the teaching, and to augment the scientific output. The rightfulness of the kind of work the clinical men are doing has always been taken for granted. It may be a mistake for our medical schools to continue to have all clinical professorships as they have been; it may become educationally advantageous radically to alter the vast tradition of relationships in which clinical teachers now live. If so, the change can doubtless be brought about in an orderly and reasonable manner, and no ingratitude should be shown to those who up to now have tried to hold the torch aloft under unfavorable conditions. Above all, all honest, earnest, hard-working men should be protected from the zeal and over-statements of headlong advocates who insinuate the "absence of ideals" among clinical men, or talk of "graft," "rascality," "commercialism" and the "exploitation of the clinical chairs for private profit."

The reconstruction in the clinical departments, when it is undertaken, ought, therefore, to be a sane and gradual process, a process of careful readjustment to changing conditions, going only as fast as men can be suitably trained and academic opinion correspondingly educated. Carried on in such a way, the reforms will be welcomed and hastened by every progressive, right-thinking clinician. Our better physicians and surgeons are broad-minded men; they are by no means devoid of the quality of self-abnegation nor of the spirit of public service; on the contrary, they are entirely capable of assuming their fair share of renunciations when conditions demand them, and of making personal sacrifices for the general good. Convince such men of the evil which exists and they will be no antagonists to the forces of reform, but, on the contrary, willing leaders of those who try to root the evil out.

After provision has been made for school-controlled hospitals, in which students may live and work, we must find places for the different kinds of clinical men—practitioners, teachers, investigators. *There is room for all three types, and all three kinds of work are desirable and honorable.* We have a homely saw to the effect that square pegs should not be put into round holes, an adage which finds its more polished equivalent in the Greek "Character is Fate." In every branch in a medical school students should come into contact with the stimulating investigator who is ever pushing forward the boundaries of knowledge; he should learn the main facts that have already been discovered from a teacher who knows how to collect them and to transmit them to others,

and he should have the opportunity of watching the example of practitioners who come into contact with all sorts of patients and all sorts of doctors, who are acquainted with the great variety of clinical puzzles which are presented to the consultant for solution and who learn the virtues and defects of the men now engaged in medical practise in different parts of the country.

After giving these matters much consideration, there is one suggestion that I should like to offer as an immediate means of magnifying the scientific productivity of our clinics and of training men for leadership in them. *Provide endowment for the maintenance, in each clinic, of a group of young scientists of proved ability and capacity for development, and relieve these men of most of the routine work of teaching and the care of patients, that they may have leisure for investigative work in the wards and clinical laboratories.* A suggested scale of remuneration for such men might be an initial salary of $800 or $1,000 per year and living in the hospital, with a yearly increase of $200 or more for the next ten years. These men, so kept at work during their most productive years—usually between the ages of 25 and 45—would rapidly increase the scientific output of the clinics, and would speedily form a group of scientific men in the clinical branches from among whom, later on, professors in medical schools and investigators in research institutes could satisfactorily be chosen. Appointed to professorships, men so selected would not need to be hedged about by too great restrictions; their training in scientific methods and ideals would have been such that they could not quickly be spoiled. There should then be no attempt to interfere with the full play of their individualities; their positions should be made as unhampered as possible; they would of themselves chip away "the spendthrift liberties that waste liberty," and devotedly give their time and energies to the advancement of the subjects they represented. Their appointments as professors might automatically cease at the end of a given term of years, or when a certain age limit had been reached.

This occasion does not, of course, permit of any full discussion of the points I have raised. Perhaps I have said enough to call some of the interests to mind and to assure you that the men connected with the medical schools in the United States, like those in Canada, are doing all they can to elevate standards and to improve conditions in that noblest of all professions—medicine.

CERTAIN IDEALS OF MEDICAL EDUCATION[1]

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It is the function of the teacher to perpetuate, by transmission to the oncoming generation, the knowledge and traditions on which civilization is based. We who have for our share of this indispensable work the transmission of medical knowledge and of medical traditions find the difficulties of getting our freight into the depots of youthful minds always numerous and often great. We, therefore, are constantly busy with efforts to improve our transactions by selecting the most valuable knowledge to transfer, by seeking devices to quicken the business, and by trying to save the labor-waste of the students. We have, besides, to add daily to our stock all the latest novelties. Despite all these pressing demands, we must keep the whole army of data in perfect order, under the command of general ideas and of natural laws. It is inevitable that the pressure on our energies should absorb most of their power so that we are habitually too busy to pause; and yet it is, I am sure, helpful to pause occasionally to consider, not the details, not the ways and means of our business, but its underlying principles.

May I regard this hour as such a pause, which we dedicate to an examination of the purposes of medical education and their best fulfillment? The function of a good medical school is to produce competent practitioners of medicine. I can not venture to call this an original idea of my own. Though it is a platitude to which all assent, it has its place here, in order to permit us to add that it is not the sole function of a good medical school, for only that medical school attains a high place, or even real importance, which adds on a large scale to medical knowledge and trains a steady succession of young men to become medical teachers. Only by the active pursuit of these high aims can the influence of a medical school inspire sound professional ideals in

[1] Commencement Address delivered before the Medical School of Washington University, St. Louis, May 27, 1909. Published in *The Journal of the American Medical Association*, August 14, 1909.

the minds of its students, practitioners to be. It appears, then, more accurate to put our platitude thus: The *chief* function of a medical school is to produce practitioners.

The Essential Qualities of a Physician

If we are to proceed intelligently, we must begin, it seems to me, with an inquiry as to what are the qualities which a physician should have, and the development or acquisition of which by students a medical school ought to render possible.

There is one quality the possession of which is the supreme need of the physician, without which he is as unfit and useless as a tone-deaf musician, or a color-blind painter. It is a quality with which every normal man is naturally endowed, just as every normal man is endowed with hearing and sight. But just as it is true that not every man can become a musician or an artist, so is it also true that for most men it is impossible to become good physicians, for the reason that they lack the one fundamental indispensable quality, that rare gift—a faculty of exact observation.

Accurate observation is by far the most difficult art which mankind has ever essayed. A nation may count on furnishing abundance of military talent—I begin with the lowest profession—plenty of politicians and statesmen, enough of competent lawyers; it may even hope to have gifted artists and authors; but it can scarcely expect to produce a single master of the art of observation in a century. It is important to realize this fact. Although the fact itself is beyond discussion, its significance is little heeded. The reasons for it are not far to seek. In most occupations a partial success is valuable; if a good result is gained it has a practical value. If a general wins a campaign, he is victorious; yet there probably was never a war which might not have been ended with less than the actual loss to the victors. A statesman whose constructive work benefits his country still does not produce perfect laws. Bismarck always dreaded the unforeseen consequences of his statesmanship. Lawyers have proved themselves useful, though litigation due to their imperfect work is incessant. A beautiful poem or picture may be a precious joy without reaching to the standard of absolute perfection. Scientific observation, on the contrary, aims for the absolute, and so far as it fails to establish the absolute truth it must be renewed, tried again and again, until every blemish is removed from it. Observation is ac-

curate and good only when it attains absolute perfection. Religion sets before us an ideal of absolute moral perfection. All other ideals of men admit of limitations, allow of boundaries, save in our waking dreams and saving else only science, which claims from us the ideal of perfect observation, which alone can reveal the absolute truth.

In most professions merit is measured by a finite scale, but the scientific observer must strive toward the Absolute, which to our human powers seems infinitely remote. Because the ideal is so lofty very few come near it. In a century Germany produces one Helmholz, France one Pasteur, England one Darwin—an American peer of these three is yet to become known.

Observation is much more than seeing, hearing and feeling. Our sensory perceptions are but the beginning, and the simplest link in the chain of processes. Yet in my experience no young man, without prolonged and severe discipline, can be trusted to forge aright even this first link on the anvil of opportunity. To appreciate the real difficulties, we must pass behind the scenes and study the mental apparatus.

The faults of the observer are to be explained not so much by the working of his eye as by the failure to work of his brain. The organs of sense are, as the physiologists have taught us, imperfect, severely limited in their scope and ever ready to furnish us with defective sensations and illusions, but they work with astonishing accuracy as compared with the mind. In my long career as a teacher of medical science, I have had only two students whose eyes were not equal to good microscopic vision, but I have never had even a single student whose mind could perceive the retinal images obtained from microscopic preparations.

Successful scientific observation depends on three psychic factors: intelligence, concentrated attention and judgment. Intelligence is necessary to guide the observer, who must before he begins have a clear understanding of the conditions by which the character of his observations is determined or modified. Above all, there must be an intelligent appreciation of what to look for, and an intelligent technical acquaintance with the methods to be employed. Only to a very limited extent, indeed, can the direct observation of natural conditions suffice. Herein, to my thinking, lies perhaps the most characteristic distinction between ordinary and scientific observation: the latter relies constantly on factors artificially introduced to expose objects too hidden or to re-

cord phenomena too remote or swift for observation. Indeed, science is based on the invention of methods of research, and the introduction of each new method is followed by an advance of knowledge. In order to realize this, we have merely to think what we owe to the methods of injection, of staining sections and bacteria, of making graphic records of the pulse and muscular contractions, of filtration and dialysis, of electric measurements, and so on through a list of immense extent. Without these numerous artificial methods our sciences would have remained rudimentary. Intelligence is, therefore, especially necessary to master methods, and no training in any natural science is more than a farce which does not give the student, first of all, a practical acquaintance with the methods used and of their advantages and their errors.

Concentrated attention we, of course, all know is indispensable, but, like other virtues, it is easier to commend than to practise. It is comfortable, after receiving a general impression, to pass on to something different with a fresh interest; but power is only for those who can sustain the closest attention for a long time, because otherwise details are overlooked, and the anticipated fact remains unnoticed. The ability to catch hold of the wholly unforeseen and significant phenomenon is the distinctive gift of a great mind. We are mentally blind to what we do not anticipate or at least know as a possible occurrence. The history of science is rich in illustrations to the point. One such curious illustration I may mention. For many years the red blood corpuscles of man and other mammals have been described as like biconcave discs in shape, but this form is to be observed really only as an artefact, and, as we now know, the corpuscles in life are cup-shaped, being hollow on one side and convex on the other. The truth has been known to us, however, only a very few years, because every one who examined the blood had a preconception of the corpuscular form, and was mentally blind to the evidence as to the real shape, of which any one can now easily satisfy himself, because his attention will be rightly directed. Innumerable instances could be compiled of scientific discoveries long missed because of failure to attend to some unexpectedly significant fact. It is by trained attention that we achieve accuracy and thoroughness; hence the first aim of the instruction in every scientific laboratory should be to impart to the student a habit of relentless attention and a high standard of exhaustive precision of observation. The quantity of information acquired is of minor importance.

Judgment is the highest quality. By attention and intelligence we may gather data, but judgment coins them into conclusions for the intellectual commerce of the world. Judgment, as here conceived, is much more than the judicial faculty, which is merely skill in balancing the pros and cons—a useful legal faculty, for the law courts deal with evidence mostly from average persons who are often biased by their interests, and in any case are ordinarily incapable of accurate observation. The law courts also follow a method, that of having opposing counsel on the two sides, which is absurd in science, though—be it confessed with sadness—this deplorable method is often mimicked in scientific debates. The scientific method is based on our belief that invariably the evidence must be wholly and exclusively on one side. If there is an apparent conflict, the duty of judgment is to find out, first, what part of the evidence is erroneous; second, what logical errors have occurred in the inductions drawn from the observations. As to the observed data, judgment must decide, first, whether they are to any extent erroneous; second, to what extent they are incomplete. For such a decision in any department of research to-day a thorough expert knowledge of the special subject is necessary, which must include not only intimate acquaintance with all previous work—a requirement too often shirked—but also intimacy with all the possible sources of error. Scientific judgment is a mental faculty which becomes efficient only after long experience and development. It is by illustrating in his own person the successful activity of this faculty that the professor of natural science exerts his most beneficent influence on his pupils.

Judgment renders its loftiest service when it deals with the logical inductions from the data. The first step logically—though often not psychologically—is the determination of the differences and of the resemblances among the data. Resemblances are far more difficult to recognize than dissimilarities and they are often as non-existent to untrained minds. Then follow the proper reasoning processes which, if successful, carry us beyond the observations to the generalization, which makes part of the growth of science.

Now the nearer a practitioner of medicine comes to possessing the gift of observation, as just described, the better practitioner he will be; and, inasmuch as it is only in science that such ideals of observation are maintained, it is evident that a scientific training is indispensable to produce physicians psychologically fit. One still sometimes hears

the distinction drawn between the "practical" and the "scientific" doctor; so far as I know, the most important difference between a "practical" doctor and the truly scientific is that the patients of the former are the more likely to die. Yet, of course, practical experience is of the utmost professional importance. Medicine is one application—only one of many—of biologic knowledge to practical needs, and the practical technic of the application must be mastered. There are useful practitioners of medicine whose utility is founded on their practical experience, but I had rather entrust myself to the care of one who had in addition to a practical technical mastery a mind educated to observe with scientific accuracy and reason with scientific precision. Those who extol the practical man and decry the scientific are of the sort who would rank plumbers above engineers.

St. Louis has had two physicians to whom I wish specially to allude, because they possessed the noble spirit of research to a preeminent degree. Their memories are held in honor wherever biologic science has a foothold. Both owe their well-earned reputations to their ability as scientific observers; Beaumont and Engelmann were practitioners, but their investigations demonstrate that they realized in their own persons the ideal we have before us. Their work has added an enduring luster to the fame of St. Louis. May they have many worthy successors!

The second quality, which both the medical student and the graduated physician must possess, is, at least in my opinion, intellectual endurance. The medical mind must work not only well, but strenuously and continuously. The period of study in America is now actually from six to eight years, since four years has become the standard of the medical schools, and admission to them demands one or two years' work in the preliminary sciences, to all which a year or two in the hospital ought to be added. During every one of these years the student must work at high pressure, mastering one branch of science after another, learning the general principles, the technical methods and the practical applications of each, and gradually fitting himself for the art of practise. Having accomplished so much, he can not for an instant relax his acquisition of further knowledge, not merely from his own direct experience of diseased persons, but also by keeping abreast all his life with the progress of medicine. He must keep up not only with the improvements in medical treatment, but also with the advance of scientific knowledge. To do this perfectly has already become impos-

sible, and the difficulty is constantly increasing. The older practitioner as he becomes busier, and his years render new modes of thought more difficult for him, must lag more and more behind the times and feel himself less and less well equipped than the oncoming young man. He is saved from discard only by his ripened judgment and his wisdom in dealing with patients. It is evident that intellectual endurance, a sustained mental power, an ever-active gift of apprehension, a ceaseless passion for knowing—call it what you will—is demanded of the members of the medical profession as of no other. Medicine is a profession which only men of exceptional ability should enter. Men of moderate gifts should seek other occupations. In the future, as medical knowledge becomes still more vast, high ability will be indispensable for those who try to master and apply it. No other profession is likely to equal it in difficulty, for the lawyers, engineers, architects, chemists and others have far less complicated problems than the physician; and their fields of knowledge are smaller. Moreover, specialization in the learned professions mentioned is far more feasible than in medicine, for every part of our bodies is related so intimately to every other part that no specialist can deal with his subject as an isolated field of practise. Not merely as in all scientific professions must a man keep up with the general progress of knowledge, but, since every organ is related physiologically and pathologically to every other, the medical specialist can not seclude himself in his chosen subject, but must preserve his active intercourse with all medical domains. The practitioner, no matter how much absorbed in work, must remain all his life a quick, diligent, alert, receptive learner. Never may he let himself feel a senescent apathy to new ideas. The ideal physician possesses a lifelong intellectual endurance.

The psychologic traits desirable in members of the medical profession are many and complex. Even were I competent to review and discuss them all, such a disquisition would not suit this occasion, and it will suffice to keep our attention concentrated on a few fundamentals. Let us, therefore, content ourselves with adding loyalty as the third indispensable quality, for loyalty best expresses that quality of single-minded devotion, that trinity of faithfulness to occupation, to purpose and to person which makes us gratefully reverence the great physician. Loyalty is a natural gift, but, like all natural endowments of character, it may be cultivated, trained and strengthened. Our entering students

rapidly classify themselves according to their loyalty to their immediate work. The best men already feel the gravity of their decision to become physicians; they appreciate the seriousness of their studies, and work faithfully each day with a prophetic instinct that each day's knowledge builds up the base for their future decisions. They are already filled with a sense of responsibility; and to nourish that sense, to sustain the loyalty of the learners should be the constant goal of the medical teachers' ambition. The student should be made to feel from the very start that his purpose in life must be to serve, and that devotion to his studies is his initiation into the life of perfect devotion to his patients.

Requirements for a Good Medical Student

The man who purposes to study medicine should have in high degree three gifts, not one of which is common among mankind, yet all of which he must have. The three gifts are: the power of reliable observation, intellectual endurance, loyalty.

If the estimate we have made of the needed capacities of a physician be correct, it follows that a good medical school can exist only with good students. Coins of full value can not be made of impure metal. We must, therefore, start with the consideration of the means to select students to the exclusion not merely of the bad ones, but also of the mediocre. We must not attempt to mint doctors from merit basely alloyed. Examinations should have their main use, not as a means of admission, but as a means of exclusion, and the more men of low and middle rank that are excluded the better. One poor student damages a whole class. We should look forward to the exclusion of all men who fail to get high marks in the preliminary tests, so that there may be a reasonable probability that all who get in are capable of hard sustained mental work and of loyalty to their studies. The examinations ought, however, to accomplish more than this: they should afford evidence that the candidate has a natural power of observation, and that the power has already received some scientific discipline, and, finally, they ought to prove that the candidate has the preliminary knowledge of chemistry, physics and general biology without which the pursuit of the medical sciences is impossible. It is a welcome sign of progress that these entrance requirements are being rapidly adopted by the medical schools of the country, and there is, I am glad to perceive, a steady advance toward uniformity. In my opinion, such a prelimi-

nary training, with the appropriate sifting of the unfit, can be accomplished by two or three years of college work—and it is not and can not be accomplished by requiring an A.B. degree (or its equivalent) unless that degree represents adequate courses in chemistry, physics, biology, French and German. Under the prevalent elective system, a man may become a bachelor of arts and yet be not only undisciplined, but also very ignorant of natural science. I have had to do with many such men, and can only say that they are so inferior at the start that only the most brilliant of them can overcome the heavy handicap. Indeed, I can not affirm that even the brilliant men are able wholly to repair the evil, for in the rush of medical study they have no time to make up their deficiencies in the preliminary sciences. They enter as cripples and as cripples still they are likely to graduate from the medical school.

Although observation is the foundation of knowledge, and no human knowledge is built on any other foundation, men of intellectual power are by no means always interested in observation. There are mathematicians who can scarcely be said to feel interest in any observations. I often recall with amusement a distinguished mathematician whom I would not have trusted to make an original observation beyond a simple measurement, and yet who condescendingly explained to a company of biologists that their science must remain inaccurate until its results were mathematically formulated. The reply might have been made to him that no mathematical result can be accurately known until put in graphic form, so that it can be observed. The one half-truth is as good as the other. Our mathematical friend had still to learn that there is an accuracy in a complex visual image with which mathematics can not even distantly vie. We might construct a scale, with the anatomist at one end and the mathematician at the other; both alike depend on observation, but one seeks his accuracy chiefly in the renewal and extension of his personal observations—he loves first-hand knowledge; the other seeks his accuracy in the logical evolution of quantitative relations, and cares but little for the simple observations on which his mathematics depends. Between these two extremes we must range those minds which enjoy and seek both observational and logical satisfaction, and who are often experimenters. Among experimenters there is a wide range in the degree of relative interest—on the one hand, in what can be directly observed, and, on the other, in the logical work following the experiment. Only those in whom the love of observation

is predominant are likely to succeed as physicians. For the pure experimenter there is plenty of room in medical science, but he can hardly find his right opportunity in medical practise.

The natural observer differs both from those who, like the humanitarians, are satisfied by second-hand knowledge, and from those who prefer experimental work, by his insatiable craving for seeing, and, to a less extent, for hearing and feeling. His inborn need is to have direct contact with the phenomena. Nothing short of the personal acquaintance with the phenomena satisfies him. Now those students who while in college elect the humanitarian studies, and neglect the natural sciences, are extremely unlikely to have the observing faculty. If they are required to study chemistry, physics and biology before they get to medical work they will be tried out, and those who have not the observer's gift will learn their limitations in time to avoid becoming medical impedimenta.

The Standards for the Medical School

Having obtained our students, we ask next: "What shall we teach them?" Really good answers to this question are given by the curricula of our better schools, which differ from one another only in detail, since in all the subjects are the same and the order in which they follow is essentially fixed.

Two comments on the present typical medical curriculum may be ventured: too much time is devoted to lectures, too little time to physiology. It is, if I be not mistaken, universally true that in American medical schools a large number of lectures are given which are mere repetitions of what is often better expounded in the text-book. It would, in my opinion, be wiser to devote many of the hours now used for lectures to practical work, restricting the lectures to general principles, the elucidation of complicated subjects, especially those which can be made clear by verbal explanation combined with drawings, models or experiments. Lectures at best can convey very little actual information, and their greatest usefulness is in exhibiting to the students the point of view, the intellectual attitude of the professor, who is not fit for his position unless his mental work is better than that of any of his students. The outlook in America is full of encouragement. Nowhere else in the world has laboratory instruction advanced as far and well as in this country. Germany must look to her laurels, for the

whole university tradition there exalts the lecture. The system is strongly entrenched, for the professors depend on lecture fees. The future of scientific education depends on laboratories, and unless European universities imitate the American laboratory standards the stream of students from Europe to the United States will soon be greater than that of a generation ago from our country to Germany.

As regards physiology, have we not to deplore the fact that very few physicians think physiologically? It is only too true that if a practitioner is asked for a physiologic explanation, his answer is usually so lame that it can scarcely be said to go. Ask an oculist why the tears run on a cold day; or a clinician the cause of pain from indigestion, or how opium works, or what is the physiologic basis of shock; ask a gynecologist why birth occurs; ask a general practitioner the cause of senescence; or ask a surgeon how the after-effects of ether are caused—and the answer is likely to be by no means in physiologic terms, by no means an analysis of functions, but rather an empirical statement; and a physiologist listening might well feel himself transported to the middle ages. The body is a functioning machine, and when it does not work properly it ought not to be tinkered by empiricists working by rules, but examined and repaired by physicians, whose chief claim to confidence is that they are expert physiologists, whose knowledge of the bodily functions guides their practise. I deem the opinion sound which regards physiology as the central discipline of medicine, and maintains that a generous development of clinical physiology is the improvement needed above all others in our medical curriculum. We are all agreed as to the importance of anatomy in medical education—it can hardly be exaggerated—nevertheless, we may feel tempted to say that physiology is even more important.

In regard, however, to material resources, our schools differ widely; and those which suffer from deficient laboratories must either make up their deficiencies or go under, drowned in the flood of the progress of the others. We have in America to-day a number of laboratories at various medical schools which are serving as present standards. All the best teaching in the medical sciences is laboratory teaching. Each one of the sciences must have a large and expensively equipped building. The building must afford a separate work-place for every individual student, rooms for the staff, rooms for advanced students and research; a lecture hall, library, and other necessary conveniences. These are

merely minimum requirements, and mean that the cost of the plant for a respectable medical school is not to be reckoned by thousands, but by millions of dollars. There is no choice. Those responsible for the financial management may be staggered by the demands of their medical faculty; they may be able to meet the demands only partially for the time being, but in a comparatively few years from now only those medical schools will be found surviving which have met these demands. With time, too, the demands are sure to become more insistent and more numerous. Never have the financial responsibilities been so great, but, I repeat, there is no choice. The laboratory education is our one sure foundation. It is indispensable that it be amply provided for; if that can not be, the failure ought to be acknowledged and the school closed.

It is in the laboratories—and only in them—that the power of observation can be disciplined and developed, and only in them that the students can acquire genuine knowledge. In speaking thus, we class the hospital with the laboratory. It is my belief, strongly held, that a laboratory is an efficient influence only when it is a place where original research goes on actively. While it is true that the informational purpose guides the daily labor, and that it is indispensable that the student make by observation personal acquaintance with as many phenomena as practicable, yet it remains also true that the student should find in the laboratory an ideal standard of work—and the only possible high ideal is that of original investigation. It is relatively easy, under the guidance of an experienced instructor, with materials carefully prepared beforehand, to confirm by actual observation the statements of the text-book.

No doubt one exclusively so trained can become a useful mediocrity among practitioners; no doubt, even, that gifted men so trained will forge ahead despite the training; yet certainly a better education is secured when the students acquire appreciation of productive scholarship, and feel themselves so near it that it is an actual and living interest to them. Old discoveries do not stir much. We read calmly that some fact, which we find stated in all the text-books as familiar to everybody, was discovered fifty or forty or two hundred years ago by a man whose name awakens no significant associations. Utterly different is the effect on the student's mind when he learns that his instructor has made a successful research and has new discoveries to report. It is

inspiring to him to know the discoverer. He feels himself a witness of the work of creation, and unconsciously his belief in the possibility and value of original work becomes a living influential conviction; and he rises at once to a higher intellectual plane. He advances on his way toward becoming a man of culture—a title which to-day only those can claim who have learned to revere productive scholarship.

Let us never forget that in contemporary education the moribund ideal is slavery to books; the nascent ideal, mastery of facts!

The consideration of our needs forces on us the conclusion that medical schools not only ought to be, but must be centers of research in order to succeed. To this end each school should be closely allied with the postgraduate department of its university, and the various medical sciences should be on a par in academic standing with the other natural sciences. Scientific students not intending to become physicians should be encouraged to enter the medical laboratories, and the highest university degrees should be as open to students of anatomy, pathology, bacteriology, physiology, etc., as to students of zoology, chemistry, or physics. If this policy be adopted with zeal, the reaction on the medical school will be wholesome, the effect on the university at large, uplifting.

The Selection of the Faculty

We have passed in review important aspects of the problem of maintaining a good medical school, but the most important factor of all, on which the successful solution of the problem chiefly depends, we have not yet mentioned; it is the corps of professors. Is it reckless to assert that no school has ever secured a sufficient number of sufficiently good professors? Perhaps no school ever will. As President Remsen has said, keenly and justly, the supply of good professors is always short. One great professor may leaven a whole faculty, but the need is for a great professor at the head of the five principal divisions: anatomy, physiology, pathology, medicine and surgery, and for first-class men at the head of the principal specialties. The majority of American medical schools certainly are without such corps of leaders.

The prevalent constitution of the medical faculties is due to various causes. First may be mentioned the survival of professors from an early epoch with lower standards; professors of anatomy who are not professional anatomists; of pathology who are busy practitioners; of clinical medicine, without knowledge of modern pathology. This diffi-

culty cures itself. A second cause is the custom of promoting local men, who are rewarded with professorships for their faithfulness rather than for their ability. Every such promotion prevents the appointment of an abler man from outside. A third cause, and the most potent of all, is the American system of appointment by the president and trustees of the university, which often amounts to appointment by the president alone.

The administration of our colleges and universities has become more or less autocratic. The university president has great power, which we are accustomed to see liberally employed, on the whole, to the immense advantage of the university cause. President Gilman's service to higher education has our fullest admiration, and there are other presidents still living who are great leaders and whom we delight to honor. We can not regret this phase of our development, though there are many now who hope and believe that it is only a phase, and who welcome the unmistakable signs of the transformation of the office, by which the university president of the future will be more a business administrator and less a minister of education. The president is likely to long remain a valuable—an almost indispensable—factor in our university life; but, in my opinion, is not likely to retain any such control over appointments as he at present exercises. This control depends on the custom of having appointments made by the board of trustees, which is typically composed of business and professional men who are qualified to advise about the management of funds, the conservation of resources and the distribution of income. The trustees ought, however, to admit frankly to themselves that their chief usefulness is, first, to increase the resources of the university; second, to determine the broad questions of general policy so as to secure a symmetrical growth of the institution. It is inevitable that the large majority of them should be inexpert in education, inadequate in their notions of scholarship, and ignorant of the needs, methods, and possibilities of most—if not all—kinds of original research. Such a board at its best can not by any possibility be a very successful piece of machinery for the selection of professors, because the members can not form a valuable judgment of their own concerning the only indispensable qualification of a candidate for a professorship—his ability to do original research of a high order. They forget too readily and too often that it is a disgrace to a university to appoint a man as professor chiefly because he is a "good teacher"—

such a man may be a good school-teacher, but only investigators can give university instruction.

In securing a faculty, the president and trustees must be guided by advice, and they undoubtedly are so guided to a very large extent at the present time. But the advice is too often gathered more or less fortuitously, and not by any definite custom or fixed principle. For our future welfare it is important to plan for obtaining the best advice, or, in other words, to make sure of good nominations being systematically presented. Accordingly, I look forward to seeing in the near future the task of nominating candidates for professorships and other teaching positions assigned to the university faculties.

It goes without saying that a university teacher must be by character and manners fitted to join a society of scholars and to come into intimate contact with young men and women. We can not, however, make every respectable gentleman a professor; but we must be sure that he has a sound, powerful, creative intellect, of which the only satisfactory proof is original research of a high order. In comparison with the possession of this intellectual gift, all other endowments are subsidiary. Professors may vary much in their ability to lecture, their availability for administrative work, in their adaptation to social life, in their capacity for business, in the quality of their minds; but all good professors are necessarily alike in the possession of creative mental power.

The selection of candidates for professorships must, then, be made by persons who can form expert judgment on the original investigations of the possible candidates. In universities, qualified judges are found in the faculties—and usually only in the faculties. To the faculty, then, ought to be given the exclusive right of nomination, leaving to the trustees only the right of confirmation; partly as a check against possible occasional errors of judgment by the faculty, partly as a financial safeguard against expense not warranted by the actual resources. This implies a radical reform in our universities; but until the time comes when teaching appointments can be initiated only by faculty action there will continue to be an unnecessarily large proportion of more or less incompetent professors.

Let us summarize the opinions expressed: A good medical school produces good physicians. The medical profession is a very difficult one, and to meet its requirements exceptional men must receive a splendid special training. Therefore, a good medical school will accept

only such students as have been selected by severe tests with high standards; it will maintain lofty ideals of knowledge, of observation, of judgment, of original thought and of loyalty. It will uphold these ideals not only by striving to furnish every important material facility in laboratory and hospital, but also by engaging able instructors. The good medical school may become great which adopts as its motto: Great professors make a great school. Let this be your device, for the greater in ideals and achievement your school becomes, the more you will help and inspire all the other medical schools in our country.

THE CAREER OF THE INVESTIGATOR[1]

By W. B. Cannon, A.M., M.D.,

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Scarcely more than a generation ago the graduate in medicine had his professional career marked out for him with a fair degree of definiteness. Private practise, as exemplified in the functions of the family physician, offered, apart from surgery, almost the only opportunity for the use of a medical training. During the past thirty years how extensively have medical activities become diversified. The paths of service that now invite the young physician are so varied that every graduate should be able to select a way for employing his peculiar powers to the best advantage. Quite apart from the conventional career of the physician, the surgeon, or the different specialists, are the opportunities for usefulness in the wide-spread movements which are socializing medicine. In professional service at hospitals and sanatoriums important work can be done; in boards of health, municipal, state and national; in public propaganda for temperance, for the prevention of infant mortality, for industrial hygiene, for the care of school children; in the campaigns against tuberculosis and venereal disease—in all these activities the possibilities of applying a medical education usefully to social needs are numerous and are yearly increasing.

Still another new career open to the young graduate is that of research in the medical sciences. For attracting young men into scholarly careers the medical sciences are, I suspect, at some disadvantage compared with other natural sciences. Such subjects as zoology, botany and physics, for example, taught in the colleges, recruit their investigators from students who, in undergraduate days, before their life-purposes are definitely fixed, find the pure interest of the science a motive which determines their whole future. The medical sciences, on the other hand, are usually presented to students only after they have decided to fit themselves for practise in a highly attractive profession—that of mitigating the physical sufferings of their fellow men. The

[1] Address to the graduating class of the Yale Medical School, June, 1911. Published in *Science*, July 21, 1911.

medical sciences become thereby merely a means to a particular and predetermined end. And not infrequently the laboratory courses, because they defer the time of coming into direct and helpful contact with human beings in need, are regarded by medical students with impatience. To men who take that attitude, scientific investigation, because of its remoteness from the distress and the critical struggles of sick men and women, is apt to seem trifling. Perhaps they look upon the investigator with benevolent interest, or as a teacher they may like him, but they will, with fair certainty, remain indifferent to his scholarly occupation.

Because the attention of medical students is fixed so definitely on the practise of their calling they may entirely fail to understand the nature of scientific research, the sort of value which it possesses, or the incentives which impel men to its pursuit—in short, they may remain quite unaware of what productive scholarship in the medical sciences really implies. Yet the work of investigation is of prime importance to medicine, and it yields some of life's profoundest satisfactions to the man who pursues it. Among the multiplying opportunities open to persons with medical training, should not the career in research be better known and appreciated? It offers such important possibilities of serving not only one's own generation, but all future generations as well, and it grants rewards so generously to those who embrace it that I propose to discuss with you some of its characteristics, and some of the qualities of those who pursue it successfully.

In a medical school as in other institutions of technical education the emphasis must be placed on what has been confirmed by experience, on what is well known and established. To point out repeatedly what is not known, or where lie the boundaries between our knowledge and our ignorance, may be an interesting intellectual exercise, but it does not alleviate the sufferings of the sick or help to meet any immediate practical emergency. Nevertheless, it is our ignorance of disease and its conditions that limits absolutely our effective grappling with many of the most distressing afflictions of mankind.

The investigator is first of all one who thinks as much of what we are ignorant of as he does of what has already been made clear. His chief interest is in the territory which has not yet been traversed. Indeed he is to be classed with explorers and pioneers. For such men the complacent contemplation of things accomplished is intolerable—

they chafe under the routine of established ways, and find the satisfactions of life in adventures beyond the frontiers. Harvey, among the first of modern discoverers, expressed the spirit of research when he wrote:

> It were disgraceful, with this most spacious and admirable realm of nature before us, and where the reward ever exceeds the promise, did we take the reports of others upon trust, and go on coining crude problems out of these, and on them hanging knotty and captious and petty disputations. Nature is herself to be addressed; the paths she shows us are to be boldly trodden; for thus, and whilst we consult our proper senses, from inferior advancing to superior levels, shall we penetrate at length into the heart of her mystery.

And in another place he wrote:

> Truly in such pursuit it is sweet not merely to toil, but even to grow weary, when the pains of discovering are amply compensated by the pleasures of discovery.

As children we all have an instinctive curiosity concerning the world about us, a curiosity which most of us gradually lose as we fit ourselves into the social conventions. The investigator is one, however, in whom this natural curiosity still persists. He has never got past the annoying stage of asking "Why?" The events occurring on every side, which are matters of course to most men, startle him into wonderment. Why does the spinning top not fall? Why do animals breathe faster when they run? Why does disturbed water take the form of waves? Why do roots grown downward? Why does the mouth become dry when one speaks in public? Such are the questions that arise. The answers to them may be incalculably valuable to mankind. The microscope revealed to Pasteur strange organisms in bad-tasting wines. Why may not the disease of the wine, he asked himself, be due to the growth of these unusual germs within it? And later when he found germs also in silkworms, the further question was suggested, Why may not animals likewise become diseased in exactly the same manner? Whether the surmises of the investigator are true, the testimony of other men usually does not tell. He must turn to nature herself and put the idea to the test of observation and experiment.

This process of scientific inquiry involves peculiar qualifications which can not be disregarded by any one who thinks of trying it. Research implies in the first place *seeking again* over a region which has been previously traversed in order to learn what other men have done and the point where their labors ended. To make progress sure,

therefore, previous records must be carefully studied. The failure to pay this just tribute to those who have labored before has not seldom led to fruitless effort or to vain repetition of work already well done. Marking the boundaries demands, then, a scholarly acquaintance with earlier discoveries; and the painstaking methods of the scholar must be used.

An ingenious and inventive imagination is a second requirement. It serves to indicate where the problems lie and also to suggest possible methods for solving them. The mind must be hospitable to all ideas thus presented, and yet it must receive them with skeptical scrutiny. By critically considering a plan for solving a problem it is often possible to select central tests, which are strategically related to the logic of the entire research. The physiologist Goltz is said to have done his most important work while fishing, for he employed that time in devising the crucially significant experiments.

Not all inquiries, however, can be ended by a relatively small number of crucial tests. Some investigations, like the important breeding experiments of de Vries, require years before they can be brought to a conclusion. Patience and an enthusiasm which is intelligently persistent are therefore essential qualities for the man in quest of new truths. The hopeful spirit is especially needed when, at the end of a long search, the investigator finds that he has only his labor for his pains—when his leading idea has proved to be false. That disheartening event is what Huxley called the tragedy of science—"the slaying of a beautiful hypothesis by an ugly fact."

The very soul of research, finally, is the highest degree of honesty. The investigator should see clearly and accurately with an eye single to the truth. He has to consider not only the observations which fit his theory, but any others as well. The erratic cases invariably make trouble, but they are often disguised blessings. They may indeed be of far greater moment than those which have been anticipated, for they may point the way to entirely unsuspected facts. In my early studies on digestion I well remember how much I was annoyed by the repeated failure of some animals to show any signs of digestive activity during the period of observation. You can imagine how suddenly my vexation changed to deep interest when the troublesome inhibition was found to be an accompaniment of fright or anxiety which these animals showed while being looked through with the X-rays.

After the investigator has completed his examination of a group of questions which have interested him, his leading idea, his tests and his results must be described with scrupulous exactness. In thus reporting his work he should strive to be like clearest crystal, receiving the light and transmitting it untinged by any trace of color.

Scientific activity implies, of course, thorough disinterestedness. The investigator asks no favors and renders none. Any intimation that he act as a retainer or special pleader, any hint or suggestion that he restrict his explorations within certain limits lest he injure cherished traditions, is a step towards the confinement of the free spirit of intellectual inquiry. Rather than surrender that freedom of inquiry or the right of untrammeled announcement of fresh discoveries, men of science have in the past submitted to tortures and painful death, and you may be sure that, if need be, they will be ready to sacrifice themselves again. So exalted is the regard in which the man of science holds the ideal to which his life is devoted that he would find in these words of Fichte his solemn pledge:

> To this I am called, to bear witness to the Truth. My life, my fortunes, are of little moment; the results of my life are of infinite moment. I am a Priest of Truth; I am in her pay; I have bound myself to do all things, to venture all things, to suffer all things for her. If I should be persecuted and hated for her sake, if I should even meet death in her service, what wonderful thing is it I shall have done—what but that which I clearly ought to do?

The satisfactions of a life devoted to investigation, like the satisfactions of other careers, arise from the profitable use of one's powers. The peculiar powers which are needed for research I have just described. The employment of these powers in perfect freedom, and the immeasurably important results that flow therefrom, render the satisfactions of productive scholarship especially keen. These satisfactions we may now consider in relation to the special qualifications of the investigator.

The requirement that the investigator learn what other men have done before him in the field he seeks to enlarge gives him an unusual realization of the part he may be playing in the promotion of natural knowledge. Knowledge grows like the picture in the dissected puzzle. Every addition must fit the parts already arranged in order to possess significance, and also every addition makes possible the fitting of new parts whose positions in the enlarging picture become thereby suddenly revealed. One of the delights of research, therefore, is the sense that every bit of new knowledge finds its place in the structure of truth, and

that sooner or later it will be required for the further building of that structure. The relation which the fresh contribution bears to that already established, the discoverer clearly sees; what relation it will certainly bear to further contributions he may never know. How little did the men who studied the minute differences among mosquitoes, and who recorded the breeding habits of those insects realize their important rôle in abolishing the pestilence of yellow fever, and in bringing about the immense social and political changes which will result from that conquest.

Because every discovery becomes the basis for further discovery the imagination of the investigator is constantly stimulated. New facts suggest in turn other facts and point to unsuspected relations between things that have long been known. Bayliss and Starling's discovery of a natural chemical stimulant which induces secretion of the pancreas led directly to the explanation of continued gastric secretion, and also to finding the marvelous mechanism by which the mammary glands are prepared for the giving of milk. Thus, though the interests of the man of science seem at the moment narrow and restricted, they may nevertheless lead his thought out into many diverse realms of knowledge. These excursions of the imagination offer repeated suggestions for fresh adventure. The look therefore is always forward to what may be seen when the next step is taken. Seeking new things becomes in time a fixed habit. Past achievements neither satisfy interest nor hold attention—they become fused with the established routine from which it is a happiness to escape. The chance of beholding unsuspected wonders, or the possibility of finding that something imagined is really true is a constant incitement to further search and furnishes the zest and interest which are among the best rewards of the investigator.

Much happiness is found also in that single-mindedness which, as we have seen, is one of the prime conditions in the pursuit of knowledge. It implies freedom from bigotry and prejudice, freedom from many of the influences and motives that to their regret men feel compelled to respect for purposes of prudence or policy. The intrusion of any other motive, save that of discovering and telling the truth, only tends to distract the mind of the investigator from his absorbing work. Faraday, whose life as a man of science was near perfection, wrote:

> Do not many fail because they look rather to the renown to be acquired than to the pure acquisition of knowledge and the delight which the contented mind has in acquiring it for its own sake? I am sure I have seen many who

would have been good and successful pursuers of science and have gained themselves a high name, but that it was the name and the reward they were always looking forward to—the reward of the world's praise. In such there is always a shade of envy or regret over their minds, and I can not imagine a man making discoveries in science under these feelings.

Single-mindedness involves also a relative indifference to those motives of money-getting which prevail in commercial life. Success in research is fortunately not measured by money standards. And yet research flourishes best where there is free time to spend in thought and experiment. This time element is essential. The investigator may be made to dwell in a garret, he may be forced to live on crusts and wear dilapidated clothes, he may be deprived of social recognition, but if he has time, he can steadfastly devote himself to research. Take away his free time, and he is utterly destroyed as a contributor to knowledge. Free time and absence of the money motive, however, are found together only among the indolent poor and the indolent rich; and the observation has been made that neither of these classes is likely to contribute men of science. The industry of the investigator which results in new knowledge—knowledge in its unprofitable infancy—does not possess commercial value. Until recently indeed any money value of research had not been recognized. In the unappreciative past deplorable instances were known of struggles with poverty and want, going hand in hand with persistent loyalty to truth-seeking. Now, however, accumulated wealth is giving leisure for men to carry on their investigations free from the worries of uncertain livelihood. What they receive may not be much, but it is sufficient to permit them to look upon the scramble for wealth without envy or regret.

Fortunately, the provisions which enable men to pursue careers in science are found mainly in great universities, through which a stream of youth is constantly passing. There men who are moved by the instinct of investigation usually find their most congenial surroundings. Freedom of inquiry is the ancient tradition of the university spirit, leisure is recognized as a requisite for meditative observation, and the youth who resort to these centers of learning can be awakened to wonder at nature's hidden secrets, and can be stimulated to undertake with ardor the struggle to possess them. The peculiar richness of university life flows from memories of the transforming powers of the progressive and original minds who have by their eagerness for the truth and their freedom from worldliness inspired their students with their own ideals.

The greatest compensation, after all, for the truth seeker is the discovery of the truth. The value of labor that brings a revelation of new knowledge does not cease with the day; it remains as a permanent acquisition for the race. There is really great satisfaction to the investigator in this thought of the "durable results of the perishable years." But not only because of the permanence of truth is there pleasure in discovery—it is the marvel of beholding for the first time an unknown aspect of nature that fascinates men of science, and through difficulties and repeated disappointments holds them to the search. Only he who has had the experience knows the thrill that comes when that which was imagined proves to be true. One who was in Faraday's laboratory when the influence of the earth's magnetism on a wire conducting an electric current was first tested, has written: "All at once Faraday exclaimed, 'Do you see, do you see, do you see!' as the wire began to revolve, and I shall never forget the enthusiasm expressed in his face and the sparkling in his eyes." Kepler knew the joy which rewards the scientific discoverer when he completed the evidence that established his third law of planetary motion. Even one whose pulses have not quickened with the excitement of discovery can understand perhaps how he must have felt as he burst into triumphant exultation:

> What I prophesied two-and-twenty years ago, . . . what sixteen years ago I urged as a thing to be sought, . . . that for which I devoted the best part of my life to astronomical contemplations, at length I have brought to light and recognized its truth beyond my most sanguine expectations. It is not eighteen months since I got the first glimpse of light, three months since the dawn, very few days since the unveiled sun burst upon me. Nothing holds me; I will indulge my sacred fury. If you forgive me, I rejoice; if you are angry, I can bear it. The die is cast, the book is written, to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited six thousand years for an observer.

The scientific investigator may not seek particularly for knowledge which can meet at once some material need. Like the artist, he is more prone to direct his efforts towards that which will for the moment properly gratify an absorbing interest of his mind. If the new knowledge has, when discovered, an immediate practical value, so much the better; but the direct search for understanding has certainly always proved the most effective motive in scientific labors. Because of this attitude the investigator should not be regarded as self-centered, or neglectful of duties to the general good. He is serving best his own generation in so far as he makes his standard of work thorough and

honest. In so far as he does that, he is serving best future generations as well, for only thus can the results of his work be used later as a basis for further advancement. And since the interrelations of phenomena are so manifold the conviction is justified that every bit of honest work can finally be utilized in forming the body of truth. Although the investigator may labor, therefore, primarily to satisfy his own curiosity, and to secure for his craftsmanship that inner approval sought by every conscientious worker, nevertheless he is making permanent additions to the world's values. There is about his life, as Professor Royce has noted,

> an element of noble play. . . . One plays with silk and glass and amber, with kites that one flies beneath thunder-clouds, with frog legs and with acid. The play is a mere expression of a curiosity which former centuries might have called idle. But the result of this play re-creates an industrial world. And so it is everywhere with our deeper curiosity. There is a sense in which it is all superfluous. Its immediate results seem but vanity. One could surely live without them, yet for the future and for the spiritual life of mankind, these results are destined to become of vast import.

Sometimes the worker in science lives to see his services used for the relief of human need. When Davy's studies of combustion enabled him to invent the safety lamp, he gave the invention freely to the world. He knew then that thenceforth for all time toilers in the mines could protect themselves against the dangers of destruction. There is no realm, however, in which the deep satisfaction of seeing discovery applied to human service is more likely to be experienced than in the realm of medical research. Consider how great must have been the joy of Pasteur and of Lister when they realized that the consequences of their investigations must lessen forever plague and pestilence and pain in men, and in the lower animals as well, and must permanently remove much of the blind struggle against mysterious agencies of disease and death. The letter which Walter Reed wrote to his wife on New Year's eve, 1900, at the end of his experiments on the transmission of yellow fever, tells something of the joy of such service—"The prayer that has been mine for twenty years," he concludes, "that I might be permitted in some way or at some time to do something to alleviate human suffering, has been granted! A thousand Happy New Years." And a thousand happy new years there will be for thousands of men and women and children, because of that one research in Cuba.

Through the employment of methods of scientific inquiry to medical problems more progress has been made during the past sixty years towards an understanding of the nature of diseases and their control

than had been made in the previous twenty-three centuries. Think for a moment of what has been learned about diphtheria and tetanus, about meningitis and rabies, about tuberculosis and syphilis, about dysentery and cholera and typhoid fever. How fundamentally our attitude toward these diseases has altered as the discoveries of medical investigators have given us insight and powers to control. What great progress we have already made in this relatively short period toward the relief of man's estate. Still we must not forget that there are immense labors yet to be accomplished. We are yet surrounded by innumerable mysteries, which can only be solved by persistent research. Not all men are fitted by temperament or training to engage in this great work, but more are thus fitted, I am sure, than are awakened to its opportunities. For those of you who are ready, here is a challenge to the supreme use of all your powers—to your imagination, your ingenuity, your patience and enthusiasm, and to your spirit of disinterested service.

EXPERIENCES OF A MEDICAL TEACHER[1]

By W. T. Councilman, M.D., LL.D.,
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When you bestowed upon me the honor of an invitation to address you to-day, it was probably because you thought that in the course of a life, more than thirty years of which have been devoted to study and teaching in medicine, I should have formed certain conceptions of study and teaching which were based on a long experience and which might have some value to the young men before me who are in the beginning of their medical career. Some of these conceptions I shall endeavor to impart, but of their value I can not judge. Experience is, after all, a long process of observation; concepts are formed early and constantly undergo correction as the field enlarges and deepens; they are of undoubted value for the individual who forms them, but of much less value to those to whom they are told. Experience can not be transmitted, and another with the same field of observation may form other and more correct concepts.

I shall take up to-day for chief consideration that part of my life which has been devoted to teaching, and the subject naturally breaks up into several parts all closely connected. The first concerns the material on which our efforts are expended, the character of the soil which we seek to till. Let us first endeavor to form some judgment of the effect of the tillage of the soil previous to the time when we in the medical schools take up our tasks. In these past years I have had under my hands a large number of young men at an average age of twenty-three. During a considerable part of the time they were divided into those who had passed through college and had acquired an A.B. degree and those who entered the school after fulfilling certain more or less indefinite entrance requirements. Harvard having required the A.B. degree as a condition for entrance into the medical school since 1900, my experience has been more extensive with students with the degree than with those without it. On the whole, the A.B. men

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are better than the men without the degree. In judging of the effect of the college training, one can not say offhand that the better material which comes from the college is entirely due to the training received there. The college has a certain advantage in that its material represents a selection. It embraces the congenital rich; others, whose immediate forebears by energy and thrift have accumulated means sufficient to give their sons a college course; and a large number of young men who go through college depending upon their own efforts for the means. There are differences in the environments of the three classes, so many advantages and disadvantages connected with each, that I am not sure whether it is better for a young man to select his great-grandfather to meet his college expenses, or place the burden upon the thrifty father or depend upon his own efforts. From all these classes come men who on the whole are rather better than the men who have not had sufficient means, or, in the lack of this, sufficient will and energy to put themselves through college.

As I look back upon my life, and the friendships I have formed through it, many of my friends having been successful, I find that a large proportion of them have not had the college degree. It must be remembered, however, that the attainment of the college degree is becoming progressively more easy and that most of these men at the present would have gone through college.

With the view of estimating in actual percentage the advantages of the college degree, I made for a number of years a comparison of the standing of the men in my course who had or had not the degree. This was previous to the year 1900 when the degree was demanded for entrance. The men were rated by the result of the written and practical examination at the end of the course, by the character of their laboratory work, as could be deduced from daily observation, and by means of the weekly recitations. Comparison of different years came out very evenly, and the general result showed a difference of between four and five per cent. in favor of the college degree. There was little difference in the best men whether they had or had not the degree, but the average was cut down by the very poor men who were most numerous in the class without the degree. Of course, such an inquiry gives very crude results which are of little value. To be of any value, the inquiry should extend over a much longer period. A college training should give much more than an ability to accomplish certain tasks more

easily. This may be accomplished by acquiring methods of study and power of concentration, both of which come with practise.

In the course of a further and more extensive inquiry, I divided the men with regard to the character of their studies in college, taking also the character of their college into consideration. The inquiry extended over a sufficient number of years and embraced sufficient individuals to make the results of some value. From this inquiry it was evident that the men who had devoted a considerable part of their time while in college to the study of science averaged distinctly higher than the men whose studies were along more classical lines. The character of the scientific studies made no difference, the most important thing being the training in observation and judgment which such studies gave. Little resulted from a comparison of the colleges; the small and the large colleges seemed to be about on a par, but I have often been able to see in some of the best students the effect of the teaching of some particular professor. One thing came out regarding the colleges which was of distinct interest, namely, that the students from strictly ecclesiastical colleges had lower grades as compared with the others and their average was even less than that of men without a degree. It is difficult to avoid the conclusion that a certain variety of collegiate training may be a detriment rather than an advantage. Saints do not seem very well to look after the colleges which bear their names, or they may possibly resent such colleges being used to provide secular education. It is also true that we should not blame the saint, for with few exceptions what can be gleaned from history would lead us to infer that saints have at best but a very imperfect idea of education. I have amused myself by extending this statistical inquiry in other ways, one result being to show that the men with names in the first half of the alphabet are slightly better than those in the last half, but possibly in this inquiry I may have had a personal bias. I have also been much interested in the individuality of classes. Classes as a whole are always different; as one looks at them in the lecture the composite expression differs, the laboratory work differs and the relations which one forms with the class as a whole differ in different years. I think that this is due to the effect of a few men in the different classes who give the class its tone.

I have been impressed with the evidence which college men often present of a lack of thoroughness in the instruction they have received.

This lack of thoroughness is not so evident in those who have had some training in science. Not only are they incapable of close and accurate observation, but they show a singular lack of facility of description. This comes out strongly in some of the exercises of the course in which the men are required to study under the microscope preparations of diseased tissue with which they are not familiar, and to give simple written descriptions of the conditions present. I must maintain that educational methods are extremely imperfect if a New England boy at the age of twenty-three has so little power of observation, combined with such deficiency of curiosity, that he can not recognize an American elm at sight, and this is often the case. I often use a tree which stands across the street from the laboratory as a test of educational methods. The lack of thoroughness in collegiate training is apparent also in regard to languages. Men who have devoted two or more years to the study of French or German have acquired no facility in the use of these languages. From my acquaintance with German students and with German universities, I have been able to make some comparisons between their methods of education and ours, and there seems to be much in favor of the German methods. Their method is undoubtedly much more thorough than is ours. Much more is demanded of the student of a corresponding age not only in the scope of work, but in the thoroughness of accomplishment. During the past year, while visiting a friend in Germany, I had the opportunity of seeing something of the German method at close range. The son, a boy of fifteen years, who was shortly to enter the gymnasium, spent in school thirty-four hours weekly, this including two hours of field work and two hours of religious instruction. In addition to this, he worked two hours daily in the evening. In the gymnasium the drill is fully as strenuous, and when the boy leaves this to enter the university he is two and a half years ahead of the American boy of a corresponding age, and his education has been conducted along rigid lines and is thorough. This rigid system of early education is a part of the rigidity of German life which has affected everything but the university. With the entrance of the student into the university everything is changed, for there he finds the utmost freedom in choice of subject, of method and of teacher. With us the conditions are reversed; we give a great deal of freedom in our rather loose early education and apply the rigidity later, for in our university work, certainly in medicine, there is a rigidity of curriculum

which is unknown in Germany. Whether there is any compensating advantage in the laxity of our early education, in the preponderating influence of athletics in our colleges which theoretically have an importance in teaching cooperation and in giving that training in mind and body which enables unforeseen conditions quickly to be met, seems to me uncertain. We give up to the advantages of our system two and a half of the ten most valuable years of life. Theoretically, the German system should tend to lack of independence of view, to a too ready acceptance of authority, but there is no evidence of this to be seen in German work. The German readily accepts authority outside of his domain of thought, but there he demands absolute freedom. With us there is a general but lax disregard of authority; our students will submit to the exercise of utmost authority in matters in which there should be the utmost freedom. The outside control which has been occasionally evident in American universities, and exercised in the limitations of freedom of teaching, of thought and expression, would be submitted to in a German university by neither the student nor the teaching body.

From this rambling talk it must be evident that I am very uncertain what should be demanded of a student as a fitting preparation for medicine. A college degree certainly seems to give advantages which are definite enough to be expressed in percentage, but there must be uncertainty as to whether the increased percentage is due to the college or to the better general average of the men who seek the college. It is of advantage that the student should have had training in some science which would enable him to acquire the scientific method. I have also found that the student is greatly assisted by having acquired some facility in free-hand drawing. Drawing is after all but a mode of expression; it helps enormously in accuracy of observation, and by a drawing the student often can convey his conception of an object more accurately than by writing. With the rapidly advancing loss of a decipherable caligraphy, some substitute for writing must be found. On the whole, there is no doubt that the entire medical curriculum will be made easier for the student and he will derive more profit from his work if he has acquired proper methods of work, and these methods can be learned in any science, but preferably in some biological science.

The next matter concerns the end sought in the medical training. The time has arrived in medicine when knowledge can be substituted for conjecture. The relief of disease is dependent upon a knowledge of the

conditions of life in the diseased individual, and this knowledge can be obtained only from the study of the sick individual. We use in this study the senses, and methods and instruments which extend them. Only those of us who have participated in the medical life of the past forty years realize how great has been the change in the medical point of view, brought about by the enormous increase of knowledge of disease. Forty years ago it was possible for the student to acquire a fairly comprehensive knowledge of medicine. The essentials in anatomy, in physiology, in pathology and in clinical medicine could be learned, the clinical methods were simple, and there was not the present dependence upon them. There was but little known as to the cause of disease, and the acute infectious diseases which are now so well known were in the same category in which many of the chronic organic diseases are at present. Indeed, at that time typhoid fever was not as well understood as chronic renal disease is now.

It is possible to name the directions in which knowledge has most advanced: In parasitology, which has taught us the causes of the infectious diseases, and in many cases what is more important, the manner of infection and the mode of avoidance; in the knowledge of the subtle changes in the blood serum which underlie immunity; in the knowledge of the function of the ductless glands and the part which they play in health and disease; in the great increase of knowledge of the anatomy and pathology of the nervous system; lastly, the more thorough knowledge of the chemical processes which take place in the body. There has been some attempt to give to the student all that is new in addition to the old. The teacher in any department of medicine is confronted with masses of facts which he feels that the student must acquire. It is true that the period of medical study has been lengthened and the lengthening has not been completed, but the attempt to place the student in the same relation to medical knowledge which was possible forty years ago is fruitless. The object to be attained in medical education is a training which will enable its recipient to be of service to the people in relation to disease. There are certain fundamental facts which have in medical education the same relation as have the three R's in the child's training, and these must be possessed of, but further than this the student must have the training and the methods of acquiring knowledge. Disease, as the practitioner comes in contact with it, affects not classes, but individuals, and the individual case of disease will always be for him a problem

to be investigated. The mere matter of diagnosis as far as naming the pathological process and ascertaining its situation is concerned may be regarded as comparatively easy, although every pathologist is aware of the number and importance of the mistakes which are made in this. As a result of disease, certain conditions which bring about functional disturbance are produced and life goes on under conditions which differ from the normal. One of the distinguishing criteria of living matter is its variability, of which individuality is the expression, and in consequence of this the result of the abnormal environment of disease must differ in every individual. The knowledge of disease in the individual, on which rational procedures of relief are based, can not come from previous experience nor from the experience of others, nor from generalizations, but must be educed from the investigation of the individual case, and in such investigations methods which aid the senses are of paramount importance. The student must have become familiar with methods by constant exercise in them, and he must have learned through the work of his teachers respect for and dependence upon knowledge. The full recognition of the individuality of disease, carrying with it the necessity of detailed investigation of every case, is the most important general conception of disease which has been arrived at. Diseases with the appropriate remedies can not be tagged and placed in pigeon-holes. It is possible to think of conditions in the individual which might modify the use of such therapeutic measures as we have even in malaria, diphtheria and syphilis. Can we so educate our men that we can turn out, on the one hand, good practitioners, and, on the other, men who are investigators, teachers and skilled in research? I deny both the possibility and the desirability of such a distinction. It is wearying to hear research spoken of as though it were a special calling demanding special methods, a special order of mind and a special environment for its prosecution. In medicine research is but the investigation by the methods of science of the problems presented by disease, and the practitioner in his daily calling is as truly engaged in research as the laboratory and hospital worker, even though he may not feel it incumbent to publish his results. The whole result of medical education should be to enable the graduate to continue to seek knowledge by scientific methods.

The practitioner will need other than medical knowledge, but it is doubtful if any process of education will give it to him. He must consider not only the sick individual, but the family, and the entire environ-

ment, and in this regard his services may be of greater importance than to the case. Disease is an important element in sociology, and certain diseases such as tuberculosis are probably more closely related to social conditions and as a class are rather to be met by social than medical measures. It is impossible for the medical man to cope fully with the duties he has assumed unless in addition to his medical training he has knowledge of the nature of man and the wide sympathy which such knowledge should bring. As I have been writing the last few pages, I have endeavored to recall to my mind the great physicians whom I have known, some through their work, others personally. Some have been teachers and writers who have exerted a wide influence, some have been active practitioners in a narrow environment beyond which their name and fame have not extended. But there is this in common: they were all of them investigators; they sought definite knowledge of disease as a basis for treatment; and they are all men of wide human sympathies.

After this dissertation on the object of medical study, which seems to me as vague as the part relating to the student, I must come to the third part,—that relating to the methods of teaching, which I fear will also be cloudy. Provided certain things are held prominently in view, there can be wide variation in methods. No two schools can be alike, since each is founded upon the individuality of the teaching body and the facilities for teaching which it possesses. There will be certain men of surpassing influence in one school and in one department, and in other schools some other department will be equally strong. It is not in the interests of medical education that all schools should be poured into the same mold.

I am still one of those who believe that teaching is a calling which, if engaged in, should be the paramount interest in life,—that it is a responsible, serious and noble calling. I regret the tendency which seems to prevail of rather disregarding teaching as a career. I have become aware of this in several ways. From my laboratory large numbers of young men after serving as assistants for a couple of years have taken positions elsewhere. In the inquiries from other institutions for men, the ability to teach is seldom inquired into, or at least little stress is laid upon it in the list of accomplishments demanded for small pay. The young men themselves in seeking positions make very definite demands as to the hours which are to be devoted to teaching. Their ideal seems to be a life devoted to research,—a perfectly proper ideal, but why not research with and through teaching? Teaching should not interrupt re-

search, for student and teacher should seek knowledge together, and even teaching involves so much of the unknown that to engage conscientiously in it is a form of research. There is too much tendency to regard research and publication as synonymous. It is a laudable ambition to be known as a contributor to medical knowledge, and while teaching may impede publication, it is, if properly pursued, a stimulus to research. There are rewards which come to the teacher alone. Who can not remember certain teachers who have exerted an influence lasting through life, and these, as models, are always before us.

Since medical education consists essentially in training in methods, study in the laboratory and hospital wards have largely superseded the old methods in which the lecture and note-book played the prominent part. I say the lecture and the note-book, meaning the association of the two, for the note-book in which the student records his observations is still an important instrument of education. In the past years there has been an enormous extension of study in the laboratory. Much of the increased length of the curriculum has been used up by an increase of the time given to laboratory study in the so-called medical sciences. It is not impossible that too much time is given to these subjects. In the old schools, for instance, anatomy was more essential than it is today, for it was in the dissecting room only that the student studied the material and received some training in scientific methods. In physiology the student in addition to the lectures and demonstrations carries out certain experiments himself, and the same methods of study are used in pathology and practically in all the departments. With regard to the importance of the lecture, opinions vary widely. I have always used the lecture method to a considerable extent, and I think it is of value provided we have a clear idea of what the lecture should aim to accomplish. However good may be the descriptive power of the lecturer, however able he may be in interesting his audience, it is useless to attempt to give in a lecture information on a complex subject. For instance, I doubt if it would be possible for a lecturer, taking a group of men of the average intelligence, but coming from a world in which there were no trees, to enable them in an hour to form such a conception of an oak or elm that they could go out from the lecture and instantly recognize such a tree. I have arrived at this view from personal experience which may not be complimentary. I have endeavored to ascertain from students before whom I had lectured on a topic in which *I*

was certainly interested, and they *seemed* to be, how much correct information they had acquired, and have found it surprisingly small in amount. I think that the lecture has a distinct place in expanding and correlating knowledge which the student has already acquired. It should also convey a stimulus to the student, and the lecture hour should form an agreeable interruption of the laboratory work. Unless the student can gain in the lecture mental recreation and stimulation, the lecture had better be left out were it not for the aspects which are not usually regarded as among its assets. One is its power of inducing gentle, refreshing, noiseless sleep in the audience, and the other is the educational value of the lecture to the lecturer. To one who is a poor sleeper there comes a great satisfaction to see sleep descend upon an audience. The lecturer experiences an exhilaration at the demonstration of the possession of a power which makes him akin to the God "who giveth his beloved sleep." I lay stress upon the condition that the sleep shall be noiseless, and position makes lecture room sleep usually of this character. I remember once on an occasion such as this of being really disturbed at the noiseful apoplectic sleep of the worthy man who had invoked the deity. With regard to the second point, how often the crudity of an idea becomes strongly apparent when the attempt is made in the lecture to convey the idea to others. How often have I seen a cul de sac rise before me into which I was on the verge of a headlong plunge! How eagerly is a friendly alley availed of as a means of escape! The teacher should find in the lecture a means of clarifying his knowledge, and in the stimulus of lecturing very often new and useful points of view present themselves.

Next to the lecturer in ascending value comes the demonstration, also a method of value, but of over-rated value. It is possible to gather a few men, not more than ten, around certain objects, point out the essential things, and enable them to see them as does the demonstrator. Such a demonstration can also be made the basis of an informal talk, and questions can be asked, but at the best it is little more than a projection of the ideas of the demonstrator.

The real work of the student is in the laboratory, for this, as its name implies, is the workshop. In this he should find apparatus and material for study and an arrangement of light and space which facilitates study. Light and ventilation should be carefully provided, for they affect greatly the character of the work. One hears something said

about the advantages of the laboratory as providing elbow instruction for the students. In my opinion, elbow instruction is to be avoided. In the laboratory, the student has the material for study, his study can be supervised and directed, but the knowledge he obtains must be first-hand knowledge and come to him from the material. I hold that it is better for a student to work for an hour over the solution of a question which presents in his work than to have an explanation which may possibly be given in a minute. In connection with his laboratory work the student should be encouraged to read. Text-books should be accessible in the laboratory, and a well-chosen library near at hand. He should be referred to classical original articles on the subjects of study. There is a wonderful freshness in an important original communication, and a stimulus is conveyed through the written page. Students differ greatly in the profit and pleasure which comes from reading of this sort. They are too apt to think that their work consists in acquiring facts. Facts there are, and they must be acquired, but the process of acquiring is very indirect, and the most important facts are always those in the distance. I have often thought it might be of advantage to substitute the reading of original work for the lecture. In the selection of reading for the students it is interesting to find how generally one chooses the early work of an author, something written under the spell of youth. There is a freshness, a directness of expression in early work which is not so evident in the later. In the beginning of laboratory work the students may require considerable help and supervision, but after a few weeks this is no longer so. I have found it convenient to divide the large class in the laboratory into smaller units of ten students. The demonstrations are given to these units, and they go to the hospitals to attend and assist in the autopsies. To a certain extent each unit works independently, for each brings from the autopsy material for further study. In this way the men help each other in their work, and each profits to a certain extent from the work of his fellows. I have not favored recitations from text-books, and have substituted for this an exercise which is held weekly, and consists in the study and description of microscopical specimens which are unknown. The papers are criticized, marked and returned. This constant criticism enables the student to place himself; he sees whether or not he is progressing, and in what direction he should improve.

I have always used the experimental method to some extent, and dur-

ing the last year to a much greater extent than before, and with advantage. Each unit carries out in turn, and under supervision, certain experiments on anesthetized animals. The experiments mainly relate to inflammation, to the circulation, to the infections, and include certain experimentally produced organic lesions. Each experiment is closely related to the subject which is being studied at the time, and the results are demonstrated to the entire class by those conducting them. The experiment clarifies, from the complex factors of disease single ones can be selected and their effect studied. How much simpler to show on an anesthetized animal what happens in increased pericardial pressure; to show the variations in an infection depending upon the route; to show the structural with the functional effects of an organic disease; to show the stages in the production of a lesion, than, without the experiment to describe, to demonstrate or to study the mere products of disease. Such experimental work demands space and facilities. It must be carried out with dignity and with the high conscientious regard for animal suffering which will compel its avoidance. Students can also be encouraged to carry out on each other certain harmless, interesting and instructive experiments on the circulation.

In speaking of teaching, I have of necessity thought more of my own subject, but I do not believe that there is any real difference in the method to be pursued in teaching any branch of medicine, or, indeed, any branch of science. It seems, however, so much easier to give the student facts, or rather those concepts which we form and in our vanity regard as facts, and to fill up the vacant places of his mind with *our* knowledge as a bucket is filled with water, but such a process is not education.

And now a few words especially directed to the young men before me. You have *not* completed your studies, you have acquired some knowledge and, more important, you have acquired methods which will enable you to go further. The reputation of your school, the facilities for study which it affords and the character of your teachers are a guarantee that you have had the opportunities. You are about to enter upon a life which will bring you into intimate relations with all the aspects of the complex conditions of disease. You will come in contact with humanity in its best and its worst aspects, for disease strips off the conventional outer covering, and the moral nature is laid bare. You will see depths of selfishness and, on the other hand, supreme sacrifice of self

for others, such as no other calling will reveal to you. You are entering upon the most altruistic of professions, one in which the best efforts of its members are directed toward the physical and moral betterment of the race. If philanthropy be evinced in deeds of practical beneficence towards the race, then Jenner, Pasteur, Koch, Reed, to mention a few names only, have been the greatest of all philanthropists. This form of philanthropy is open to *you*, there are numbers of questions awaiting solution by *you*, and the knowledge which *you* may give the world may be of inestimable benefit. The world knows as the philanthropist only him who gives money out of his superabundance, which is, after all, a most uncertain way of conferring benefit, but the only one which is open to many, and which most of us think is not availed of to a sufficient degree. However, you need not concern yourself about this form of philanthropy, for it is almost impossible that it should come in your way to exercise it. You must make up your mind in the beginning that your life is going to be arduous, that there are few prizes, that the road to even that degree of financial success which will enable you to establish a home and family in comfort is now and is becoming increasingly difficult. One of the reasons for this is that disease as it affects the masses is being recognized as the chief of the social problems. This recognition is seen in the growing provision of hospitals and dispensaries, in the pure-food laws, in the wider extension and increased efficiency of the work of boards of health. Such work will not diminish, but will increase. Tuberculosis is being more and more removed from exclusive medical care, and the success which has attended the modern methods of caring for it will be extended to other diseases. The medical inspection of schools and factories are social measures and diminish the importance of your efforts, which concern chiefly disease in the individual. This is an age in which increased efficiency of effort is being sought in every direction, and there is a great loss of effort in the practise of medicine. In spite of all this, one of your duties will be to so educate the public with which you come in contact, in knowledge of disease and of factors causing it, that social measures can be made more effective. As an offset to the fewer individual patients which the future will bring, there will be increased demand for physicians employed in a public capacity, an increasing number of medical positions in institutions of various sorts will have to be filled.

In your outlook on life be optimistic. There may be some germ of

truth in the idea that optimists, like poets, are born and not made, but optimism is more easily attained than is the poetic faculty. A man is an optimist or a pessimist according to his vision, for, contrary to the adage which implies a distrust in vision, "Things are always as they seem." If you do not possess optimism, acquire it, for there can be moral as well as religious conversion. There is much good in the world, rather more than evil, but possibly not so obvious without vision trained to recognize the good. You can go through life with the environment of a stony desert, or you can walk through green fields, and hear babbling brooks and the songs of birds and the voices of children at play, and rest in the shade of mighty trees by the banks of rivers, all depending on whether you see good or evil.[2] Do not be afraid of the future; trust your own powers. It is a great thing to know, and you may accept it, for it is true, that success comes to the individual who under all circumstances does his best; and one will always do his best in that work which gives him the most joy in the doing. There is no criterion for success and reward, for both depend upon the point of view. There is an abundance of work to do, and room in the world and food and water and raiment for the honest worker, and the greatest happiness lies in work.

"Little do ye know your own blessedness; for to travel hopefully is a better thing than to arrive, and the true success is to labour."—R. L. S., "El Dorado."

[2] On critically reading this, the writer feels that some further elucidation is necessary. Of course, it is possible for a man to create about himself a fool's paradise in which he may dwell in happy contentment. He can quickly create such an environment by well-selected stages of alcoholic intoxication. The great trouble comes with the voluntary selection of optimism as a career. To most men, evil becomes deterrent by its exhibition in others. Thus, to the pure in heart, vice by demonstration is made abhorrent; to earnest, sober men, drunkenness is unattractive, and an agent at times so useful as is alcohol may be totally condemned. Although some may temporarily cover themselves with a cloak of optimism, using it as the wolf used the sheep skin, the only genuine and constant optimists are the beneficiaries of a protective tariff, syphilitics in the early stages of general paralysis, some successful clinicians, who turn to financial use their God-given intuitions of disease, and some presidents of colleges. The revelations of optimism which one gains from these sources make the state of mind seem unattractive. But on the other hand if the world as seen seems good don't change your glasses.

MEDICAL RESEARCH: ITS PLACE IN THE UNIVERSITY MEDICAL SCHOOL[1]

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If there be one word which is heard most frequently in the most intelligent circles interested in professional education to-day, it is the word research. In our own country in recent years medicine has fallen under its sway, and on all sides efforts are being made to meet its demands by the erection and equipment of costly laboratories within whose walls research may be carried on in a continuous and orderly manner.

Granted that the governing bodies of our great universities have familiarized themselves with the significance of this word and are giving it out, some only with the lips, others with a thorough conviction that to it must be accorded a permanent place in our higher institutions, the problem of how to deal with such a costly, and in many ways unattractive, offspring, how to correlate it with the teaching function, how to cultivate it side by side with the routine methods of instruction, will occupy a prominent place for years to come.

Research signifies effort directed toward the discovery of laws and principles through the systematic collection of new, and the better correlation of existing, data. It also means effort directed toward the more efficient and economical application of discoveries to the welfare of man, in other words, the utilization of latent and hitherto wasted energy. The aims of research are not culture, not miscellaneous information, not a mood of leisure meditation upon the origin of things, but mainly utility and service to mankind.

The chief influence at work in lifting medicine from a mere teaching to a research level is the same as that at work throughout the world of science and in fact in all intellectual fields. If we examine it more closely we find it akin to the breaking away from authority and dog-

[1] Address before the Harvard Medical Alumni Association of New York City, November 26, 1904. Published in the *Popular Science Monthly*, April, 1905.

matism in religious affairs and from autocracy in the government of nations. Its foundations rest far down in the great liberalizing wave of the nineteenth century. We no longer believe that each step in advance is the ultimate one, but only one in a series toward ultimate truth, and this fact makes us realize that we must keep on marching. Research recognizes no immediate boundary to its activities, and no limit to its possible acquisitions. In placing only a temporary value upon its constructive plans and using theories only as aids to new facts, science grows in candor and modesty with its achievements.

In biology and medicine, the spirit of research takes into account the continual movement and flux in living things and their environment. It is a study of change, of transformation, brought about by conditions which may or may not be under experimental control. We describe carefully and minutely, not for the sake of the picture and its details, but chiefly to be able to recognize the change. Unless we know the consecutive pictures how can we detect the movement and its trend? It is the moving picture of the kinetoscope that has gradually replaced the single view in repose.

But there is danger that we may move too rapidly and find our advanced positions untenable. The world is just now very optimistic and expectations run high. If we give way to the feverish haste of our day, the slow, sure advance of medical science may be brought into discredit. For it is one of the features of this feverish haste to leave the position held as soon as possible for one more advanced. We move away because we have some doubt as to the security and trustworthiness of our present position, and we hope to gain by pushing beyond it rather than strengthening it. As a result of this attitude we find the thing most characteristic of the day and age is the rapid remolding of our stock of information. Revolutionary views are uttered from an inadequate basis of observational and experimental data. Theories become kaleidoscopic in their variety. Old views long since discarded come to the surface like old fashions. All this change and ferment is both the cause and the effect of the enquiring attitude of mind. Research begets new data and the opposition to these begets new research. Thus the fermentation is kept up and a froth several years deep lies on the surface which few can penetrate.

This haste and hurry is part and parcel of what might be called nature's lavish waste of energy. The volume of our information in-

creases more rapidly than our knowledge of the principles which underlie and support it. The progress actually made is more apparent than real. It is a swaying to and fro with but little forward movement. Like the driftwood of which the waves are endeavoring to unburden themselves, many excursions back and forth must be made before the fact is finally landed. It is often much battered and barely recognizable.

That there is here a golden mean to be followed need not be emphasized. The spirit of research should be properly tempered by a true insight into the relation of enquiry to the great accumulation of knowledge and the reserve forces stored in the every-day experience of mankind and handed down from generation to generation.

In the meantime the optimism of the world which unknowingly assumes that medical science can rise above natural law and correct any and all excesses of individuals and communities must be met by a better education in natural science rather than abandoned to the manipulations of the charlatans of physical and mental healing.

Passing now to the more obvious external conditions which have tended to stimulate medical research, we may single out a few which have been of special importance. Perhaps the most ancient and strongest of all is the desire in the human breast to maintain health and prolong life. From its very beginnings the healing art has been weighed down with the greatest of problems, to save life and to cure disease, often in those of lofty estate, and its status for the time being frequently depended on its success or failure in accomplishing apparently the impossible. In our own day the crumbling of the formal religious belief that this life is but a preparation for that beyond the grave and the centering of our efforts to make it as much of a success as possible, the growth of wealth and leisure and the pursuit of sensual pleasure, these various motives, high and low, combine to exert a pressure upon medicine which is scarcely equaled in other professions. To save life and to cure disease are imperative demands which grow more urgent, more impatient each year, and which suffice to quicken the efforts of the scientist and the true physician as well as the charlatan, and shape almost every problem which is considered worthy of attack to-day.

As a most important and timely contributory force to the advancement of medical research in recent years are the princely gifts of benefactors, with whom we especially associate the names of Johns Hopkins,

Garrett, Fabyan, Rockefeller, McCormack, Payne, Morgan, Huntingdon, Sears, Stillman, and many others without whose aid medical research could hardly have commanded a corporal's squad to-day.

A factor not to be neglected in the advancement of medical science is the feeling of national pride. Most of the medical science of the past and much of the current knowledge has on it the mark "made in Europe." To-day this mark is occasionally being replaced by the label "made in America," and without doubt the home market will soon be well supplied. Fortunately, tariff barriers and trusts do not interrupt the currents of knowledge. Without hindrance we have filled our storehouses from the old world and I trust that we may repay in due time some of our huge indebtedness. Our national pride once awakened will see to it that our country, the wealthiest in material things, shall continue to give as well as to receive the fruits of the intellect.

These are forces acting chiefly from without. Perhaps the most important acting from within has been the use of animals. The study of the great domain of infectious diseases has revealed such a similarity between the diseases of man and the higher animals that we hesitate now less than before to apply courageously the knowledge gained in our experiments upon the highest mammals to human physiology and pathology. Without this aid from animal life, medicine as a progressive experimental science would dwindle into insignificance. Moreover, the artificiality, the rigidity and awkwardness of the medicine of a generation ago have been largely dissipated by its contact with biology, which brought with it the comparative point of view.

Side by side with the use of animals we may place the convenient use of bacteria and other microorganisms in our laboratories in producing disease as one of the great levers of pathological research to-day. They have enabled the investigator to establish important centers of research completely independent of and coordinate with those connected with the hospital and the dead-house. The latter, it is true, still remain a final court of appeal for all discoveries destined for the relief and cure of human diseases.

In the historical development of science the research instinct appeared at first sporadically, and until recently it was simply the spontaneous flowering of the scholarly mind in the highest institutions of learning. To-day it has been actually organized not so much to train

youth as to produce useful knowledge. This new organization of research has been greatly favored by the promise of valuable returns in the suppression of infectious diseases of man and animals. Most of the institutions founded thus far were created by public authority for this purpose. It was realized that such work must be pushed forward rapidly to secure results of value to public health and economy.

About twenty-five years ago special laboratories began to appear. Our own government figured among the earliest in voting what were then very liberal appropriations for the study of infectious animal diseases. At the same time came the German Imperial Health Office and somewhat later the Institute for Infectious Diseases in Berlin, and the Pasteur Institute in Paris; more recently there have been established the Institute for Experimental Therapy in Frankfort, Germany, and the many sero-therapeutic institutes and public health laboratories, nearly all of which have become noted for their research work. In our own country we have last but not least the Rockefeller Institute for Medical Research of this city and the Memorial Institute for Infectious Diseases in Chicago. Most of these were created to deal scientifically with problems of immediately practical bearing. But it does not need a prophet to foresee that following them others will arise which will devote themselves to broader and more fundamental problems and which will attack those left unsolved by the former institutions. Of this latter class the Pasteur Institute in Paris and the Rockefeller Institute are conspicuous examples.

The founding of research institutes does not guarantee their success. That will depend upon the men who work in and for them. It has become evident that our research workers must have more diversified training than the older generation possesses. The store of knowledge accumulated by science must be made available to medicine. The only way in which this can be accomplished is to have trained men continually examining and testing this accumulating store of facts and applying them to the problems of disease. Such men should have medical training and approach their problems from the medical point of view; but to them should be spared the necessity of learning ultimate details of the medical art and they should give their energy to some sister study, be it morphology, physiology, chemistry or pathology. Medicine has just begun to realize the need of drawing to itself the great talent which hitherto has had an open door only to the pure and applied

sciences. Research is largely dependent for its successful pursuit upon an attitude of the mind which insists on following a clew that promises to reveal some relationship, some law of causality, between phenomena hitherto apparently unrelated. This type of mind has many of the attributes of the inventor who is attempting to combine to our advantage the forces of nature in new and unlooked-for ways and to express them in the form of labor-saving machines. In order to attract these minds we must pay them a living wage and provide workshop and tools, and exercise but moderate restraint over their activities. To them the exterior of practical medicine has a forbidding aspect. We must bring them to face its really wonderful problems through the portals of the laboratory.

After we have established research institutes and brought together a devoted, enthusiastic group of scientists we must not look too closely at the immediate practical value of research. Most of the epoch-making discoveries have had little, if any, direct influence on medical practise at the start and even for some time after. Some have wholly failed to yield hoped-for results, but they have had great influence in unexpected directions. This is chiefly because great discoveries are as a rule not ripe for use. To point out a hitherto unrecognized cause does not thereby enable us to overcome its effects. These may be grounded in centuries of adaptation. A great discovery frequently does no more than call attention to a new fact without defining its relationships. The discovery of the tubercle bacillus for example left the whole question of its complex relation to a given host untouched. The same may be said for most other microbes. The delicate equilibrium between parasite and host is the thing to be worked out before we can rationally proceed to upset it in our favor. There is therefore no need of hurrying to put discoveries to use. Many are discredited because of such ill-advised attempts and the investigator himself becomes discouraged in the futile effort to apply principles which fit only in part the practical condition to be influenced.

The tendency to make research directly prove pet theories, find short cuts to health, and cure diseases hitherto unsuccessfully treated will continue to give the investigator trouble for some time to come. What is needed is that at least a small number of scientists work at these problems of disease as we would at the other phenomena of the world around us. They should look them over from all sides calmly

and objectively to get at the lessons expressed in them. They should look upon pathological manifestations as the normal sequences of causes operating under special conditions and for certain periods of time. They should endeavor to analyze phenomena rather than attempt to suppress or crush them. That function should belong to the health officer and the practising physician.

In order to take this calm attitude toward disease as a natural phenomenon and attempt to explain it, it may be necessary to move backward toward simpler problems from man to the higher animals, from these to lower types, from the complex processes of the human machine to the physical and chemical phenomena of the inorganic world. This has not always been the attitude of medicine, for standing as it does under the too near and impending shadow of suffering and death, it was but natural to attack the most difficult and complex problems first.

It is needless to say that the position of the research worker of the immediate future will not be an easy one. The strain to produce something is far more wearing than teaching. The mental play of the teacher's mind to produce something is relaxation compared with that of the investigator to carry out a contract for the delivery of new knowledge. The gap of years and even generations may yawn between the problem in hand and actual solution. It may indeed prove to be wholly impregnable from the point of attack. It may be solved by some obscure genius with slight facilities who happens to hit the combination which unlocks the secret.

We have all experienced the burden and complexity of growing information which has not reached the stage of actual knowledge. Extensive tables of figures are laboriously built up around it and the worker himself becomes encrusted and almost asphyxiated with methods and technicalities. We find the laboratory growing hot and stifling as we painfully add one more fact to the heavy burden. Suddenly and quite unexpectedly the true discoverer comes with a simple explanation. At his approach the air is cleared and freshened. Tables and figures are shoved to one side, and we begin our work once more with improved vision along another road.

Such is frequently the mission of the true discoverer, to leap over mounds of facts and figures, bring us back close to nature and show us that her movements are often far simpler than we dared imagine.

Thus far I have dealt with research as a thing by itself to be furthered by endowment and prosecuted by specially fitted men for the sake of its value to mankind. This is only preliminary, however, to the main thesis of our remarks, the training of research workers and the relation of research to the medical school. As a humble representative of the school which has provided so liberally in its new buildings for both research and instruction I must endeavor, amid the tangle of changing conditions, to place before you the relation between teaching and research as it presents itself to me.

I am quite inclined to make a sharp distinction between the physician and the investigator, and I think the time has come to create as it were a separate genus. What may be said of the type research worker should also apply to the teacher.[2]

Some enthusiasts would go so far as to urge that all students be made research workers. This is clearly uneconomical, for not many are fitted and the world has no use for many. There are needed chiefly well-educated, humane, upright and patient workers who are ready to do the routine tasks of their profession. The physician must keep step with the great procession as it slowly moves forward. He can not deviate much to the right or to the left nor move much faster than the rest. His activities are more or less defined by a consensus of opinion. No matter how much he may swing his pinions in the laboratory, they will have but little room to move in the practical work of life. It is one thing to discover, and another to apply, one thing thoroughly to believe in our results, another to make others believe and act accordingly.

The research worker on the other hand deals more with the undefined boundaries of knowledge and with the frayed edges of sound information. He does not march with the procession, but he must do lonely outpost and scouting duties. He must seek clandestine meetings with those of other sciences, for he learns mainly by breaking through conventional barriers. He makes his discoveries unknown to others, and the farther they are in advance of the times the less attention they will receive.

[2] The time is not so distant when it will become necessary to separate the functions of teaching and research. The teacher will then investigate to improve his teaching, the investigator will teach to clarify the aims of research. One merges insensibly into the other. The attempt to set apart the teacher and investigator is simply another tributary of the current which is tending to make all teachers independent of the practise of medicine, by urging adequate compensation for their entire time.

Again, the physician under the stress of practical life must be positive and aggressive in his dealing with disease. He must supply empirically what is lacking rationally, and his experience is therefore of the greatest value as it is in all vocations which couple science with actual life. The investigator, on the other hand, must be to a certain degree negative, skeptical of current theories, and suspicious of mere experience. He must frequently destroy before he builds up. He approaches the individual case of disease through general laws established through experiment. The physician must begin with his patients and through them reach general formulæ governing disease. He studies the patient, whereas the investigator studies the disease.

The investigator should be free to a certain degree to create his material and his problems. The physician must accept his cases as they come to him and he can only exercise the skill of selection. Each patient is indeed a problem, but it is worked out under the illumination of the accumulated knowledge of the world, and not dealt with according to strange and hitherto unknown formulæ. The physician can not control his patient excepting within a narrow range. Experiment as such, except when of a trivial nature, is forbidden by law and conscience. Statistics is the only court of appeal he has in attempting to prove success, and this method we know is open to serious error. On account of his peculiar and unique life work, the physician must build his education as broadly as possible and carry as much information as is compatible with normal thinking. The research worker, on the other hand, digs and delves and he must leave unnecessary encumbrances behind.

The main task of the medical schools will always be to train physicians. It does not fall within the scope of this address to define what this training should be, and I shall not attempt it, excepting in so far as it bears upon laboratory instruction. I believe that the medical school should make the future physician absorb as much as possible of the best medical science of the day and give him a certain initial skill and dexterity in carrying out the fundamental operations of the medical art. The power of the student to think independently, to digest the facts he has absorbed into some current theory which enables him to absorb more, and thus continually upbuild and rebuild his science, should be uninterruptedly stimulated by lectures, conferences and reading. To aid this constructive work laboratories have come quite

generally into use. They are not research institutes at bottom, but originally a means to fix and illuminate through the senses facts otherwise meaningless. For the average student the laboratory is a review as well as a fixative of data which he is to carry with him and upon which he is to build his professional experience.

Those who are inclined to claim for the laboratory more than this in the education of the physician, I would ask to consider how little of medical science can actually be presented there to the student. Certain functions can be demonstrated in physiology, certain processes and products in chemistry, certain anatomical facts and certain parasites as etiological factors in pathology. The prolonged impact of untoward conditions, the silent movement from health to disease, the shadowy boundary between the two who can adequately demonstrate them in the laboratory. There the days, months and years of disease processes must be concentrated into minutes and hours. Much of the laboratory work is like the ward visit, a fragment, to be pieced out through the agency of books, lectures and the imagination.

I am of course fully aware of the great importance of thoroughly training the senses and the powers of observation. The chief means of communication of the physician with his patient is through the medium of the senses, and the more avenues of intercourse are opened between him and the diseased body by increased delicacy of sense perceptions and by instruments of precision which aid and control the sense impressions, the more precise the diagnosis.

Lest I be misunderstood, I wish to emphasize the importance of bringing the student who is to be the future practitioner in as close contact with laboratory research and its immediate fruits as possible. For he will be the one to apply new points of view, gained experimentally, in the prevention and treatment of disease. Unless he gains some confidence in the laboratory and its methods and is ready to welcome its fruits how can medicine make any progress? His own contact with the laboratory should be for him a strong support and create in him faith in the ultimate triumph of science over the problems and mysteries of disease. Its influence should reach far beyond his years of training. When in practise he is disturbed by the confusion of voices, which, like the will-o'-the-wisp, lead neither here nor there, or when he is perplexed by the movement of fads and fashions pointing now in one, now in the diametrically opposite direction, when he comes to real-

ize that much of his professional work is still empiricism and that it moves from precedent to precedent, he will look back upon his best laboratory work with a feeling of relief and recognize in it the germs of the science where his results came true if he worked accurately, and where he could predict the outcome. This power to predict which characterizes science should stimulate the trained physician to urge on in every way his profession toward the scientific ideal. If the laboratory succeeds in creating a desire to aid in realizing in the student this ideal its work will be well done. This craving to place his profession on a more and more scientific basis will lead to steady intellectual growth and insight and a proper receptive attitude toward the progress of science.

Much confusion can be avoided, I think, by classifying laboratories into two categories, those that inculcate principles of medical science and those which subserve clinical diagnosis. In the latter, clinical medicine or medical practise seeks to lay hold of the acquisitions of experimental science and to utilize them in the interpretation of symptoms. The clinical or hospital laboratory approaches medical problems from the professional side and is thus an extension of medical practise into a territory where science and practise meet and shade into one another. Here the future physician should receive most careful training when he begins to direct his studies toward some branch of medicine. For this important stage the Harvard Medical School has left the fourth year open. In this year the student should utilize all possible means of combining his practical training with the more analytic methods of the laboratory and exploit whatever it may offer in more accurate methods of making and recording observations. At the same time, we must not make the mistake of calling this research. It may later on shade into research, but it is at first simply increasing and perfecting the means of identifying already well-known disease processes.

We are just now passing through a period of reaction against so-called book learning which is likely to lead us too far in the other direction. So much weight has been placed upon the training of the senses that we are in danger of neglecting the mind behind them. It is vaguely assumed by some that laboratory work is *per se* research. This is far from the truth. We might with profit carry on researches in the published work of others without entering the laboratory. We might, on the other hand, spend our whole life in a laboratory without

acquiring more than a little manual and optical dexterity. We are in danger of forgetting that the training of the observational powers is simply developing another language made necessary by the expansion of medicine as a biological science. The true investigator may have but imperfectly trained senses, but he may still succeed in discovering and opening up a new country to us. With his intellectual power to grasp and arrange data, largely worked out by others, perhaps, he finds his way through the unknown.

In our zeal to further the educational methods of the day, there is just as much danger that we overload the mind with too many sense impressions, as with too many facts gathered through the medium of books. Have we not heard of the absurd waste of time in some laboratories over work employing laboratory technique which is as empty as the written page to many a student? Have we not seen many a laboratory servant whose senses were sharper than ours on occasion; many a butcher who detected abnormalities of the tissues more quickly than we? Yet they were not "doing research." Let us not deceive ourselves concerning the true inwardness of research. It does not consist in trained senses alone. It is a quality, an attitude of the intellect working through the senses. Claude Bernard clearly recognized this when he said: "He who does not know what he is looking for will not lay hold of what he has found when he gets it."

Though research may be carried on and is going on in all departments of medicine to-day, yet the true home of the investigator is the modern laboratory. Here we have a kind of reproduction in miniature of the actual field of work, where, by means of physical, chemical and biological methods of analysis, the problem in hand may be reduced to as simple terms as possible or at least confined within more or less governable conditions. When it has reached a certain stage of maturity, then facilities should be at hand which enable the investigator to approach cautiously the very complex conditions of actual disease in the hospital and its special laboratories.

The university medical school has thus two duties to perform, to train practical men, physicians and health officers, and to encourage the few who incline to research. The methods of training for both coincide for a large part of the course, but they must eventually diverge, the practical man to enter the actual field of conflict with disease and forge his weapons as well as he can from the storehouse of the world's

accumulated experience and science, the investigator to continue his struggle with the stubborn and evasive facts of nature.

To carry out this program the university school must have teachers who are investigators, well-equipped laboratories both for large classes and for individual advanced workers. It must have satisfactory operating rooms and stables for small and large animals, for the experimental and observational study of animal diseases is the logical outcome of laboratory research. It is another intermediate station on the way to human pathology. It frequently presents such strikingly clear solutions of difficult problems and permits us to introduce the comparative method which has been so fruitful in the biological science. Closely associated with the school should be hospitals and clinical laboratories. Let us look at a few of these requisites very briefly.

The training and encouragement of research as well as thorough teaching in our medical schools lead by implication to the doctrine that professors should be investigators themselves. For the purpose of elementary class work it may be maintained that it is enough for teachers to instruct with the aid of all the paraphernalia of the day. But what shall they teach? Shall they go no faster than the successive editions of text-books allow, or shall they express an opinion about or actually teach the newest doctrines? As I stated before, the knowledge of the world is covered with the froth of research fermentation of several years' depth, and the latter yields about as much genuine knowledge as the froth does actual fluid. The teacher can not well sound its depths unless he has made some independent studies of his own. Then he will be able to say something definite, whether he has been at work in this very field or not. His critical view will enable him to take sides and be positive rather than negative in his teaching.

It will no doubt be maintained by many that to teach undergraduates the latest information is out of place or at any rate not necessary. All that they need for their daily subsistence pertains to fundamental conceptions. But I answer that we really know little of fundamental conceptions and what we believe we know is being affected and modified by every new discovery of any value. It is of the utmost importance that the theories which the graduate takes with him be as sound and withal as fresh as the teacher can make them, for they will form the scaffolding of his thinking for some time to come, possibly for many years.

The teacher who is called upon to direct the work of students who are beginning to feel their way into unknown territory or who have already left the beaten path far behind must of necessity be an investigator. Without going ahead of them himself his counsel is apt to be wavering and at times he feels himself wholly helpless to advise. In other words, to direct research the teacher must be playing the chief part while his students, of whatever rank, should take subordinate parts all definitely working toward a given end. Only by such cooperative coordinated work can both the worker and the task become a success. The teacher's capacity for research is not necessarily measured by his productivity. This may be curtailed by his high standards of what should be put on record. At the same time his capacity for research should somehow make itself felt through those whose labors he is directing. His fruitfulness should be manifested through them. If a teacher remains sterile both in himself and his students he has missed his vocation.

Of importance equal to that of an efficient body of teachers are adequate laboratory facilities for both teaching and research. Medical science has moved beyond that stage when a student could be kept profitably employed with a microscope and a box of slides. With the growth of laboratory methods of diagnosis, more varied and costly apparatus is needed, more space to place it and more laboratory service to guard it.

In research the demands are similar, but more exacting in certain directions. Some still believe that abundant space and work room with cases full of the latest instruments will certainly lead to great discoveries. These are, to be sure, necessary; but without the motive power behind them are more than barren; they create the debts rather than the assets of research. This motive power consists of enough assured income to carry on research and develop the research powers of meritorious students. There should also be ample means for laboratory service. Research is in one sense a business, the laboratory a workshop. Here all sorts of processes are under way and as no one would expect a workshop to be carried on with only a foreman, so a laboratory can not be kept in use without laboratory service. Hitherto assistants have been made the motive power and the laborers; but this system should no longer be maintained. Not only is it wasteful to fill the time of assistants with routine manual labor, but it is wasteful in so far as the

laboratory is dismembered at the end of each year. Every laboratory should be in working order even if all assistants are lacking. The trained laboratory servant should represent the routine and conservative, the assistants and investigators the progressive, element.

With the growth of the cost of research it becomes of great importance to exercise care and selection in admitting men to research positions. Fortunately there are not many collateral attractions in a life of research and the process of elimination acts as a rule automatically. Still there is danger just now that some of the flotsam and jetsam caught in an eddy or else afraid of the current of practical life may seek the quiet of the laboratory, because of some imagined taste or capacity which fails to materialize later on. It is far better not to have any research workers than poor ones.

The leaven of research which has so completely permeated and revolutionized all doctrines and practises of medicine in the past quarter century is still acting and no one can foretell how it is going to mold the medical science and practise of the coming decades. No one can foresee what it is going to do with the medical schools.

There will come without doubt much change in the artificial boundaries of the present so-called departments. Created for purposes of teaching and administration, they are a veritable bane to the investigator who can not stop mining because his vein happens to dip into another man's superficial territory. Even in the routine of teaching many changes are likely to come. I believe there will be developments in two main directions. The present laboratory studies, or propædeutics, will be deepened and extended in the direction of the more exact sciences, or toward the physical, chemical and biological work of the university proper. As a necessary result of this movement much of the work now done by these departments will move forward into clinical medicine and surgery, and there will be a corresponding growth and strengthening of the clinical and pathological laboratories of the hospitals. To illustrate: Much of what is taught to-day in pathology belongs to clinical medicine and surgery, for it is largely special and diagnostic in character. The pathologist is now the servant of the physician and surgeon in completing and rectifying their diagnoses. The pathologist of the future will deal with more general phenomena derived from experimental and comparative data, just as the physiologist has moved onward, or backward if you please, into general and

comparative physiology. Similarly, the burden of other new scientific departments will be shifted into the more practical branches to make way for more fundamental problems. The logical outcome of such a rearrangement of studies would be eventually a college course arranged wholly with a view toward medicine and sanitary science, in which the bulk of the present early studies of the medical schools would find a place, and, secondly, a practical course in medicine, surgery and sanitary science, in which clinical, hospital and public health laboratories would take a prominent part. It may be that in this way the time and energy of the student aiming for two degrees and a livelihood could be saved, while the efficiency and scope of the course could be increased at the same time.

The establishment of research institutes by governmental authority and private munificence marked the beginning of a new epoch in medical science by organizing research and giving it an assured status. The influence of these institutes upon research in the university medical schools will be watched with much interest. Unless the latter take a more definite position and furnish opportunity whereby investigations of a more serious and exhaustive scope may be undertaken, the research institutes will absorb the best men and the highest class of work and leave research, as heretofore, a by-product of the schools, often desultory, discontinuous and trivial. To avoid this impending calamity, the professors should be relieved of various routine duties incidental to the management of laboratory workshops. There should also be appointed investigators of definite rank whose teaching should be subordinated to research in such a way that the latter will not be seriously impaired by long interruptions.

In conclusion I wish to dwell briefly upon a phase of our subject which is perhaps the most important of all and toward which the various lines of our discourse have been converging.

The relatively large endowments given to medical education and research in recent years have created as it were a trust to be administered by the medical profession in the interest of human society in the broadest and highest significance of the term. This I interpret to mean that we must endeavor to make all advance in our knowledge of health and disease common property so far as this may be possible, to disseminate broadcast the benefits of research into the laws of health, so that they may enter into and form an integral part of the life of the

individual and the community. We all know that much of the daily work of the physician goes to charity, that the public health authorities and sanitary officers are but scantily compensated for their arduous and often dangerous labors. There can be no question that as a profession medicine stands at the head in disinterested service; but there is still room for improving the relation between medicine and the public. How can this be done?

Perhaps, next to the education of physicians of the highest standards, the immediate duty of the university medical school is the development through research of preventive medicine and sanitary science and the education of sanitary officers. This, it seems to me, is the best way in which our debt to society can be discharged; for it is the way through which medicine has moved during the past quarter century to its present commanding position; it is, in fact, the way of least resistance for the human race to evade or mitigate the penalty incidental to advancing civilization. Preventive medicine is the application of medical science to the mass as well as to the individual. It attempts to arrest disease before its momentum has carried it beyond the means of help. It is the truly modern as contrasted with the medieval point of view.

Nobody will deny that much has already been done in the development of preventive medicine and sanitary science. It will be claimed, and with justice, that more has been done than the public is willing and prepared to accept and live up to. We know that to-day municipalities continue to permit the unnecessary sacrifice of lives to epidemic disease, that politics is permitted to disorganize efficient boards of health in large and small communities and to put the best material interests of family and social life into untrained hands. We know that the public continues, in spite of warnings, to consume noxious drugs, widely and boldly advertised in the daily press. These difficulties are very real, but they should not discourage us. The medical profession is in a sense to blame for this condition; for the household remedies and cures of to-day are those of the doctor of a generation ago, and the medical practise of to-day will crop out in the daily life of the next generation. Likewise, the indifference of the physician and health officer of a generation ago is reflected to-day in the attitude of the mass of the people.

The university medical school has here a great function to perform,

for it is the legitimate source of knowledge pertaining to hygiene and sanitation. There are few problems which have not been suggested by contact with disease. Sanitary science is broad and rests upon many foundations, and the means of disseminating its teachings are many, but its origin is in pathology. Without the stimulus of the continual presence of disease its problems may become trivial and its practise ineffective.

The university medical school may in still another way hasten the diffusion of sounder views concerning health and disease by creating more interest among the educated in the general problems of pathology. This is but the obverse of physiology, and its principles, once scientifically founded and objectively developed along general and comparative lines, should form an attractive study in all biological laboratories. We are still some distance from the realization of this suggestion, but the task is worthy of the best men in our best schools.

If we take this broad view of the work of the university medical school and try to put it into effect, medical science will come out of its somewhat isolated position and take its proper place beside the other sciences. The work of the physician will then be rated more justly, because the great complexity of the problem of health and disease will be more appreciated. His services will then be sought more frequently before rather than during the calamity of illness, because it will be better understood why he can more easily forestall and prevent than cure disease.

THE OUTLOOK IN MEDICINE[1]

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It has once or twice before fallen to my lot to address the freshmen at the opening of the session in other universities. But I believe that this is the first occasion on which I have essayed the more formidable task of speaking to a graduating class. I feel it is a more formidable task. The freshman is young and ingenuous, not hypercritical, disposed to be pleased, and upon the whole if anything rather too prone to believe that his teachers must know a great deal more than himself. I remember once asking a colleague what subject he would suggest for a talk at the opening of a certain medical school, a talk which was to be directed chiefly to freshmen. He replied, "Why, almost anything will do, only morality and good advice have been rather overdone of late." I do not know what the present condition of the market for morality and advice may be here, nor whether the demand may be greater among graduates than among freshmen, but in any case I do not feel any special call to assume the roll of moralist or counselor. It occurred to me, however, that it might be of some little interest to those who have just been admitted within the portals of our ancient and world-wide profession to hear from one who has now been a member of it for well-nigh twenty years, whose studies were carried on under different conditions and under a different sky from yours (not on the sunny banks of the Mississippi, but by the gray shores of the Firth of Forth in far-off Edinburgh), a few words on the changes and the contrasts which those years have brought, the tendencies they have developed and the vistas they have opened up for future progress. I shall concern myself mainly with the outlook for the future, if for no other reason than this, that you are at the age and have reached the point in your career at which the future is of more absorbing interest than the past. It is needless to say that in my reading of the skies I make no particular

[1] Address delivered at the commencement exercises of the Medical Department of the University of St. Louis, May, 1907.

pretense to be weather-wise above my fellows. Any man who has been identified with medical research and education for fifteen or twenty years, nay for a much shorter time than that, if he has had his eyes open, must have remarked certain tendencies, a certain trend in our progress. To note those tendencies, to heed the straws which show how the wind blows, to mark the set of the tide, does not need uncommon sharpness of vision. That is the extent of my soothsaying.

I desire then to consider, so far as such a vast theme may come within the time at my disposal here, the outlook in medicine, with what incidental retrospective glance the subject may invite. I propose to consider the subject under two heads: the outlook in medical education—the outlook in medical investigation. I shall not trouble you with details. I could have informed myself first, and then you, how many medical schools in the country have bacteriology in the first, and how many in the second year; how many colleges give more than 60 hours to the teaching of practical physiology and so on, and from such data I might have been able to deduce, by properly juggling my statistics, the practical conclusion, for example, that 51⅔ hours is the ideal amount of time for obstetrics in a well-balanced medical curriculum. I do not say that such enquiries are unimportant, but I have spent too many hours on them elsewhere to be willing to spend minutes on them here. In any case it is the broad features of the subject which attract me and on which it will probably be most profitable for you that I should dwell.

I. The Outlook in Medical Education

When I began the study of medicine twenty-four years ago at the University of Edinburgh, the old system of teaching by lectures (a whole hundred of them in each course) was in full swing. In physiology the lectures were very good of their kind and well illustrated by lecture-table experiments, although considerable imagination had often to be exercised by students sitting on the back benches of a room containing four hundred men in order to picture to themselves, for instance, the appearance of a frog's gastrocnemius muscle as it contracted. Of laboratory work there was practically none. One quantitative estimation by Fehling's solution of the sugar in a specimen of urine, half an hour's coquetry with a laryngoscope, and an equal length of time spent with the ophthalmoscope in wooing the optic disk, usually, alas, in vain, com-

prised the whole of my practical work in physiology, so far as I can remember. In histology we had a very fair laboratory course, and gross anatomy was well taught according to the old style. Botany, zoology and chemistry, with some anatomy, occupied the whole of our first year. In the second year surgical lectures and dressing in the surgical wards were taken, as is still, for some inexplicable reason, the case in the Scottish universities. You can imagine the grip we got of surgery, with our anatomy not half learned, pathology untouched, and physiology, including histology, just begun. In the third year we had pathology lectures, with a fair course of pathological histology and the chance of acquiring such knowledge of gross pathology as we could pick up by sitting on the benches of the post-mortem room. Of bacteriology we got not even the smack. A couple of years after I graduated in medicine I attended the first course of practical bacteriology ever given in the medical school of the great University of Cambridge. It was mainly taken by men of considerable seniority. Such fledglings as medical students, were, if not actually warned off, at least but little in evidence.

In materia medica, which included pharmacology, we had lectures alone; the so-called practical class in materia medica, which was voluntary, although the fee for it was not, as I well recollect, being, to say the least, of very doubtful utility. The work in clinical medicine in the wards was good, as it had been ever since bedside work for students, under the name of clinical clerking, had been introduced by Hughes Bennett, one of the physicians to the Royal Infirmary and professor of the Institutes of Medicine, now usually called physiology. Our fourth year was occupied by obstetrics, a hundred formal lectures again. You could not buy goods of that kind at that particular shop in smaller quantities. Gynecology was as yet hardly differentiated as regards its subject matter from general surgery, although the teaching of it was included under obstetrics. The fourth-year work included also a homeopathic dose of skin diseases, and a good filling, substantial meal of medical jurisprudence, washed down with hygiene, or, as they called it, public health. Vaccination was watched at a dispensary. No student, to my knowledge, ever performed the little operation himself. Of instruction in ophthalmology or diseases of the nose, ear or throat, we had none. Nevertheless for the time I doubt whether on the whole there was any better undergraduate course anywhere in the country, or for that matter in the world, as regards practical ward instruction in clinical medicine.

The general educational requirements for admission were by no means high, and the proportion of graduates in arts or science among the medical students was insignificant. These details may be of some interest to American students because the early medical schools in this country, such as the Medical Department of the College of Philadelphia, established in 1765, and the Medical Department of King's College, New York, now Columbia University, established three years later, were modeled on the University of Edinburgh. The celebrated Dr. Benjamin Rush was professor of chemistry at the former.

Progress has been made since the time to which I refer both in Great Britain and in this country, but particularly here, so that it is not too much to say that the best of our American medical schools are fully abreast of the best in Europe. One might go even a little farther than this, perhaps, without straying beyond the bounds of strict truth, but I prefer to quote on this point the words of an eminent medical educator in Great Britain, Professor Schäfer, of Edinburgh University. In an address at the opening of the session of the Medical Department of the Yorkshire College, Leeds, in 1903, he made the following pronouncement:

"It is certainly not a little remarkable that the American universities when placed in the possession of adequate endowments, make no attempt to increase the number of their graduates by a lowering of standards, . . . but aim entirely at attracting students both by the thoroughness and efficiency of their teaching and by the facilities for postgraduate study and research which they offer in all departments of science and medicine. The natural result of this must be that these universities will not only obtain the pick of the American students, but will, as years go on, attract students . . . from other countries, so that eventually the center of gravity of medical science will become shifted westward. This must certainly be the result of the development of the universities in the States, which will eventually take the part which was played by the universities of Italy in the Renascence and by those of Germany in more recent times unless by the munificence of the private benefactor, or direct and adequate endowment by the state, our own universities are placed upon a footing which shall render it possible for them to compete, by thoroughness of equipment and the adequate provision of a staff qualified in the highest manner for both teaching and research, with those which are now by virtue of the pos-

session of these requirements outstripping us upon the other side of the Atlantic."

The most important changes of the near future, actually accomplished in one or two of our foremost schools, in progress in others and bound to come in all that hope to survive in the struggle for existence are, I believe, the following:

1. The influence of the professional medical educator should predominate over that of the amateur. Medical education must more and more be considered a branch of pedagogics.

2. An increase must be made in the general educational requirements for admission. The freshman must bring more knowledge in his head and perhaps more cunning in his hands to the medical school. Above all he must bring the trained brain which already knows to a certain extent how further knowledge may be most easily acquired. How high the standard should be raised is a question where differences of opinion may be properly entertained. It is to some extent a local question. Nothing would be more foolish than to aim at a uniform standard all over a country as extensive as this, the different parts of which are in very different stages of development, although a minimum might well be established. There must, however, always be, as regards this question of entrance requirements, best schools and second-best schools, but it must be carefully looked to that the second-best schools are good enough.

3. A more general insistence on a sound knowledge of physics, chemistry (inorganic and organic) and general biology before entrance, so that the whole of the four years may be devoted to strictly medical work, under which head I of course emphatically include anatomy, physiology and pathology.

4. The introduction of the laboratory system of instruction more extensively and more intensively, and in order that time may be found for this, curtailment of the number of lectures, especially in subjects like anatomy.

5. Most important of all, the introduction and the extension, where already introduced, of real bedside work in the wards, both in medicine and in surgery, of course under responsible supervision. The work in the policlinic or dispensary is of great value, but can not take the place of the continuous study of the natural history of disease which is possible to the student who works in the wards. To obtain the best conditions

for this sort of work, medical schools must have hospitals attached to them and under their complete control. It seems probable that one of the developments of the future in medical education will be the building and endowment of such hospitals. Large funds will be required for this purpose and a large fund of patience and persistence in educating the public out of its prejudices, and let me add in educating our rich men or our legislatures out of some of their money.

6. To aid in effecting a synthesis between the scientific and the clinical work special chairs may be established, such as the chair of experimental medicine recently endowed at Cleveland. The foundation of such chairs, it is scarcely necessary to say, far from obviating the necessity of the development of a more scientific type of clinical investigator and teacher, will in fact emphasize that necessity.

7. The establishment of laboratories of public hygiene and preventive medicine and provision for the training of medical officers of health. This country must follow Europe in national, state and municipal hygiene. In the crowded countries of the old world the majority of the population already lives in cities. It is of vital importance that the conditions under which they work and the environment in which they live should be made as healthy as possible. This is a problem which is not yet as acute in this country with its immense rural areas, but it is by no means remote and it is forcing itself more and more into the foreground each year. Let me repeat one of the prime necessities of the near future here in America (I said "the near future," but the problem is with us now) is the provision of an efficient and well-paid body of medical officers of health, who after acquiring some experience in practise shall adopt public hygiene as a life profession. Undoubtedly the present system of precarious political appointments can not last.

II. The Outlook in Medical Investigation

When I began the study of medicine antiseptic (and aseptic) surgery, or at least that modern and thoroughgoing development of it initiated by Lister, was little more than fifteen years old. It was scarcely yet universally accepted even in Edinburgh (with Glasgow), the cradle of Listerism, where Lister was himself for a time professor of clinical surgery. Old Professor Spence, who filled the chair of surgery while I was still a student of arts, never to his dying day convinced himself that there was very much in the new method of treating wounds. For years after

I started my course it was antiseptic rather than aseptic procedures which were relied on. Crude and cumbrous too were the methods by which the surgeons endeavored to free the wounds and keep them free from germs. The air was pungent with the carbolic-acid spray. The kettles, atomizers you would call them, sizzled and fizzed; nurses, assistants and operator worked in a cloud of spray which was by no means agreeable to nose and eyes. When wounds were being dressed in the wards a miniature steam engine accompanied the surgeon on his rounds. With all precautions suppuration was common, although of course far less so than before the days of Lister. Slips of technique which would now be considered unpardonable in an interne were committed daily in that great hospital by men of international reputation. One of the surgeons to the infirmary, a professor in a university, a man in the prime of life, by no means fossilized in his ways, one would say, habitually operated in an old frock coat, which apparently was kept in the hospital for the purpose, and did not seem ever to have been cleaned. I remember well that when he turned up the sleeves, as he always did before he began to operate, old blood stains were all too visible on the lining. He was a surgeon of considerable repute; the operating theater was filled with students from all quarters of the world, for Edinburgh at that time was perhaps the most cosmopolitan of all the great medical centers and on it converged a crowd of students of all colors and nationalities, especially, of course, representing every part of the British Empire. All this was sixteen or seventeen years after Lister published his epoch-making paper on "A New Method of Treating Compound Fractures, Abscess, etc." In that paper he refers as the foundation of his new method to the experiments of Pasteur on the bacterial origin of putrefaction.

I need not dwell upon the immense impetus which the firm establishment of aseptic and antiseptic methods imparted to surgery in all its branches. Obstetrical practise was scarcely less affected. Since my time (if you please I do not consider myself an old man) a generation of practitioners has grown up which accepts the Listerian methods as axiomatic. They have been so drilled and disciplined in surgical cleanliness that it has become to them a second nature. I suppose it would be physically impossible for any one of you young gentlemen to perform a surgical operation in an old frock coat.

Let me revert for a moment to the fact that when I was a student

bacteriology was still a novelty, considered by many to have little practical value. It is true that it was beginning to excite interest among the more alert and open-minded, and particularly among the younger members of the profession, but it was considered quite outside the ordinary medical curriculum. It was just the year before I first matriculated as a medical student that Koch published his discovery of the tubercle bacillus, a discovery which has revolutionized our ideas of the causation of tuberculosis, has placed in our hands the means of greatly limiting its spread, and eventually, we can hardly doubt, the means of eradicating it from the world.

Malaria was still the mysterious scourge it had ever been. The proof of its transmission by mosquitoes has given a great impulse to tropical hygiene and bids fair in the future to render habitable and healthy some of the most beautiful and fertile regions of the earth now deadly to white men. The discovery by an illustrious American, Major Reed, that yellow fever is propagated in a similar way has done much to rob that pest of the Antilles of its terrors. Incidentally it has greatly facilitated the construction of the Panama Canal.

I need scarcely say that the treatment of diphtheria by antitoxin was undreamed of at the time to which I refer. Tracheotomy as a last desperate device when suffocation was threatened was the best resource of our art.

In the study of the internal secretions, a study which has now assumed such practical importance, a beginning had been made in the elucidation of the relations, of the thyroid to the economy. But nothing was as yet known of the fundamental rôle played by the pancreas in carbohydrate metabolism, and nothing of the secretion of the pressor substance epinephrin (adrenalin) by the suprarenal gland. The physiology of the pituitary was also a terra incognita. While much still remains to be known of the function of the hypophysis, its exploration has now hopefully begun.

For the future it seems clear that important discoveries in the etiology and treatment of various bacterial diseases are still to be anticipated. Pneumonia, which now runs its course without check by medicine, will, it may be confidently hoped, be curbed. Malignant growths, of whose very causation we are in perfect ignorance, will, we may well believe, in time, yield up their secret and become tractable to some surer and less terrible therapy than that of the knife. Recent work on the suturing

of blood vessels and the transplantation of organs may possibly enable us in the future to substitute in some cases a healthy for an injured or diseased part. A great extension of the field of nerve surgery may enable relief to be afforded in hitherto incurable affections of the nervous system.

It is to be expected that medicine, including surgery or mechanical medicine, will depend for its progress more and more on experimental work in the laboratory, and probably it will be found expedient for research as well as for teaching, and indeed still more for research, to erect separate foundations to fill the gap between the laboratory and the clinical work.

Organization and Endowment of Research

A few words more may be permitted to emphasize again the necessity of great endowments for the future development of medical research both for laboratories and for hospitals. This is a matter which is not thoroughly understood by the general public, by our moneyed men, or by our legislators. Everybody knows that for ordinary material benefits humanity has to pay in labor and in money. We are digging a canal down there at Panama. Suppose somebody said, "Nature obviously intended a canal to be dug there. It is bound to come. It is only a question of time. Sooner or later we shall have the canal, anyway, and there is no use making any special effort about it. We can not much hasten or hinder it." Would you not all recognize that he was speaking nonsense? But when we read in the daily press of the wonderful triumphs of medicine, how malaria or yellow fever or diphtheria has been conquered and shorn of its terror, we are led to believe that apart altogether from human effort, or at least apart from organized effort, apart, above all, from the expenditure of hard cash, we shall some time or other gain the mastery over cancer and pneumonia and all the other diseases that have hitherto been our masters. We sit down and congratulate ourselves that, much having already been done in the way of medical discovery, much more will surely be done, but too often with the tacit assumption that it is none of our business, and that all we have to do is to read in our morning papers of those wonderful achievements after they have been accomplished. But is that the way you do about the canal? No! The matter is agitated in the press and in the country. It is discussed in congress. Surveys are made, rival routes

considered, estimates prepared, and when the whole matter has been thoroughly threshed out, the government of this great country undertakes the work, primarily in the interests of the United States, but incidentally for the benefit of all mankind. The president goes to the Isthmus to give to the work the imprimatur and the impetus of his presence, and you pour your treasure and your energy into the undertaking till you have opened a path for the commerce of the orient to New Orleans and New York. But this you say is a work of national and international importance. And the cure, or prevention, or extirpation of tuberculosis and pneumonia—what kind of a work is that?

Nobody expects that a Panama Canal will be dug by the chance efforts of philanthropic engineers and philanthropic laborers who for love of their work, for love of their kind, or for love of fame will from time to time, as the spirit moves them, devote themselves to that great undertaking. No! Such works are accomplished either by private corporations possessed of great resources who expect to reap rich profits from their enterprise and by their paid employees hired at a wage fixed in the ordinary way by the haggling of the market, or they are accomplished at the public cost and for the public benefit. It is one of the glories of science, and of medical science as much as any, that in all ages men have been willing to sacrifice their material interests, and the interests of those dear to them, to fill their hours with unpaid toil of the hand and of the brain in the hope of enlarging the boundaries of knowledge. In the face of neglect, of opposition, sometimes of actual persecution they have continued their noble work, and the world which was not worthy of them, which ignored or laughed at their labors, has made no scruple of profiting by their discoveries. Even in our day, when such matters are coming to be better understood, there are still many who seem to think that in science discoveries are made by chance, the wind blowing where it listeth, men dreaming new things in their sleep, and that it makes little difference in the output whether research is encouraged and sustained by the fostering care of governments or private benefactors or whether it languishes in neglect. I believe that in the future clearer ideas will prevail in regard to this matter and that it will be perceived more generally in this country, as it is to some extent already, and as it has long been in Germany, that in science as in everything else, upon the whole the world will get what it pays for. Take any one of the burning practical problems of medicine, some of

which I have already alluded to and which I make no apology for repeating, the causation and the prevention or cure of malignant disease, of pneumonia, of scarlet fever, of arterio-sclerosis, of nephritis, of diabetes mellitus or what not. What do we know about them, and how are we going to increase our knowledge? Does anybody doubt that when we know more we shall be able to do more, to control, to palliate or to cure, to prevent or perhaps to eradicate some of these diseases, to limit the toll of human life which they take year in and year out?

How soon we shall be able to do this depends in all probability upon the amount of well-organized, well-directed investigation concentrated upon them. The greater our efforts the sooner shall we be rewarded with results. And the larger the amount of money appropriated for these purposes, other things being equal, the speedier and the surer will be the harvest from the efforts of workers already enlisted, and from those of new workers drawn into such investigations from other fields. This night in the city of St. Louis children are sickening and dying, men and women are being cut off in the prime of life, and ill health is embittering and sterilizing the lives of thousands even where it is not curtailing them, all because we do not know enough. It is as sure as anything can be, I believe, that the wise expenditure of money in sufficient amount in the last fifty, it may be in the last ten years, perhaps even in the last year or last month, would already have placed in the hands of the profession effective means of preventing some of the deaths which will take place this night in your city, perhaps among the acquaintances, it may be among the friends of some of this great audience. I wonder if there is any rich philanthropist, or any present or prospective legislator (or his wife or his sweetheart) within reach of my voice. If so I want to reason with such, lest perchance some feeble word of mine (insignificant causes do sometimes produce great events) might as an arrow from a bow shot at a venture strike the mark. Yes, it is true, I say, people are dying now whom medicine or surgery might save had some rich man seen his privilege, or the state its duty in the past, perhaps in the past year. People are dying now because scientific investigation has been starved and discouraged by unwise parsimony or sheer indifference on the part of those who had the power to aid. Talent has been spending itself in less important fields which might have been attracted into this high career. Consider what the state does in other relations. It fosters agriculture, it fosters commerce, it often grinds its

people to the dust by costly preparations for war as the alleged safeguard of peace. I am not quarreling with these things, not even with the costly preparations for war. On the contrary, in certain circumstances we must all applaud them. But has the state then no duties to perform in the war on disease? I am going to make a suggestion which I suppose is an exceedingly foolish one. We know that shortly a Congress of the Nations is to assemble at The Hague to consider various questions of international law and international relations. Several of the countries represented desire to bring the question of the limitation of armaments before that august tribunal. England wishes them all to go more slowly in the building of battleships. A modern battleship costs at least six to eight millions of dollars, and as things are going at present is fit for the scrap heap in ten or twelve years. No, I am not going to trot out once more the idea cherished by many noble hearts and apparently entertained even by such hard heads as that of Mr. Andrew Carnegie, that we can by calling war wicked, wasteful and absurd decree that the millennium shall begin next Monday morning. The abolition of war and warlike armaments is not practical politics for our generation or our century. My suggestion is something much more modest. What a magnificent endowment for research in medicine the price of a *single* battleship would be! Suppose now that at The Hague each of the great naval powers were to agree to forego the building of one solitary battleship and to put the money into laboratories and hospitals, primarily for medical research, incidentally, and none the less beneficent need this secondary use be, for the diagnosis and treatment of disease. Or lest the audacity of such a suggestion should startle the world of statesmen and diplomatists (they of course are always listening to hear what may be said in St. Louis even by the most insignificant individual) let us not claim the price of a battleship from each power in perpetuity, but only the interest on it for a term of years, or until such a time as some definite object, such as a knowledge of the etiology of cancer and the development of an effective curative procedure for it were accomplished, the principal sum then to revert to its original purpose if the nations concerned still felt that they positively could not get along without those particular battleships. The capital sum would still be intact and they could throw it into the sea with the other vast sums which have been squandered on that particular result of human folly, pride or panic.

And now one more personal word. I sincerely congratulate you who have entered to-day into the ranks of our noble science and craft. If I have read the future aright the sky of medicine is bright with promise. Never was our science so interesting, our knowledge so varied and so rich, our art so capable of good to individual men and so closely interwoven with the common life of cities and nations. Never did the doctor occupy so high a position in the estimation of mankind, or deserve to do so. I have cast my eye back over a period of more than twenty years and noted our progress in that time and speculated upon the triumphs still to be won. Should one of you twenty years from now, on some such occasion as the present, indulge his fancy and consult his memory in taking stock of the position and prospects of medicine at that date, he may chronicle a record of achievement beside which the boasted triumphs of the past two decades may sink into insignificance. But if this should be the case, depend upon it these blessings and these triumphs will never be obtained "on the cheap." The future victories of medicine will not be won by the bare and unarmed hands of the solitary enthusiast, but by drilled and armed battalions. They will come as the result of the strenuous and sustained and well-directed efforts of numerous trained investigators working on an adequate scale, with adequate resources at their disposal.

Money can not buy great discoveries nor the genius by which they are made. But it can buy the resources and opportunities for lack of which genius is too often hampered in its work, and it can attract to science from less important spheres talent which may be wasting itself in lower forms of effort. Let then our legislators ponder it, let our millionaires take note, money properly applied will bring results in medical science as it will in agriculture, in industry and in commerce, fabulous results it may be, astounding percentages of blessing and healing for the nations.

PROBLEMS, METHODS AND ORGANIZATION OF RESEARCH, WITH SPECIAL REFERENCE TO PHYSIOLOGY[1]

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When Dr. Barker did me the honor to invite me to address you this evening he suggested that a physiological subject of a general nature rather than a detailed discussion of a particular research would be most appropriate. He indicated further that as far as possible the subject should be treated without the use of technical phraseology. I shall endeavor to meet his wishes by considering in a perfectly general way and without any care for formal completeness some of the main problems with which our science is at present busied, or will in all probability be busied in the immediate future. In doing so I shall mention without going into detail some of the methods which seem to afford the greatest promise of success in attempting to solve these problems. I hope there is somebody here who knows less about this subject than I do. If so, I wish to be understood by those who know more, and I am quite aware that several of my audience must be included in this category, to be directing my remarks entirely to him. If I am the most ignorant man among us in regard to this particular theme, and since I began turning it over in my mind, I am quite prepared to admit anything you like about it, will you be kind enough to consider that what I seem to address to you is in reality a soliloquy. But *revenons à nos moutons.*

The General Problem of Physiology.—In a sense we may say that physiology has but one problem, the description, interpretation, explanation of all the peculiar phenomena which we associate with living matter. I shall not discuss the meaning of the terms, "interpretation," "explanation," when used in this sense, nor shall I inquire whether when we "explain" the occurrence of a given phenomenon, for example when we explain the swelling of the colored blood corpuscles in a

[1] Address before the Biological Society and the Medical Club of the University of Chicago, January, 1903.

hypotonic solution (*i. e.*, in a solution containing a smaller number of molecules in the liter than the blood serum) as due to the lowering of the osmotic pressure of the liquid in which they are suspended, we in reality advance beyond the description of the "how" to the explanation of the "why." I shall decline also to entangle myself in the discussion of the question what we mean when we speak of one phenomenon being the cause of another. These inquiries form a portion of the subject matter of philosophy and metaphysics. Some of the keenest intellects that have ever been vouchsafed to the sons of men have spent themselves upon them, generation after generation, with results or without results, according to the standpoint from which you judge their labors. Assuredly these questions are not without interest, ay and fundamental interest, for all investigators of natural phenomena. But it will be sufficient for our purpose if we consider that a phenomenon is explained when we have completely unfolded its relations to the other phenomena which in the observed orderly sequence of nature always precede it, and the causes of which are known, and that the causes of a phenomenon are known when stage by stage we can deduce the occurrence of this particular phenomenon from the state of things which we consider ultimate or beyond further analysis. For example, in the present condition of our knowledge of physics and cosmology, the general problem of physiology might be considered completely solved if, given the nature, number, distribution, mass and movements of the elementary particles (molecules, atoms and electrons) of all kinds of living matter at any particular moment, and the nature, number, distribution, mass and movements of the elementary particles of all the unorganized matter acting on the living matter, we could from mechanical considerations deduce the whole cycle of changes occurring in the life career of all the particular kinds of living matter. Here the problem of the origin of life is not supposed to be included in the scope of physiology, and it is assumed that no other forces are concerned in the phenomena of life than the forces of the inorganic world. But if we adopt the hypothesis that living matter was originally developed from dead matter on the surface of the earth (an alternative hypothesis, as you are aware, is that of Lord Kelvin, who suggests that the primal germ might have been carried from some extra-terrestrial region by a meteorite) a complete solution of the general problem of physiology would include the explanation of this development. Again if we adopt the vitalistic hypothesis

in the only sense in which as I conceive it can be held by a modern physiologist, the general problem of physiology would be to determine in how far the phenomena of living matter are the outcome of the forces with which we are familiar in unorganized matter, in how far they are due to a special "vital force" acting of course in conjunction with "ordinary" physical and chemical forces, and what the nature, manifestations, and possible transformations of this vital force are. And let me take the opportunity to remark that there is nothing necessarily absurd in the idea of a peculiar form of energy pervading all living matter. The chances at present seem to be in favor of the ultimate explanation of life on mechanical lines. But while the phantom of vitalism must never be permitted to divert us from pushing our physical and chemical researches to the utmost, the philosophical inquirer will scarcely care to assert, at the present stage of our progress, that it is *impossible* that a peculiar vital force should exist.

I have purposely displayed the general physiological problem before you in all its breadth, in all the vastness of its scope, in order to impress upon you the fact that its solution is only practicable, if at all, by the successive attack of much more limited and special questions. The "vaulting ambition" which will not deign to occupy itself with any but the most general problems and neglects the cultivation of the narrow though fruitful fields of special research, is extremely likely to "o'erleap itself and fall on the other side," and while certainly more respectable than the prejudice which refuses to recognize the wider aspects of physiology at all, has perhaps been not less a hindrance to physiological progress. At the same time let me say, and say it emphatically, that the man who has no clear idea of the goal, the grand *dénoument*, so to speak, to which all physiological research should tend, will fail to make the most even of his special experiments by failing to fit them into the fabric of which they should form a part, just as if a builder working without a plan were to waste a world of toil in the hewing and chiseling of stones that he is never to use, or which when built into the wall were out of proportion or out of plumb. There is very real danger that when one does not take a broad view of the aims and a broad outlook over the field of physiological research, he will fail to see the connection of the fact which he discusses with other facts, and a collection of isolated and unclassified facts is no more a science than a heap of stones is a house. As Claude Bernard said even in his time, "Physiology is the funda-

mental part of medicine. Nevertheless, the physiological facts discovered in the laboratories are becoming so numerous that they threaten to encumber medical science and to obscure it, if one does not investigate the laws which relate them to clinical facts, and thus trace the first lines of experimental medicine."

In a word, unity must be given special research by keeping the general problem in view. Fortunately it is not difficult to do this, for if we conduct our special inquiries in a proper way, we shall find that when followed into all their consequences, they inevitably conduct us at last to the general problem of the nature of living matter.

Let me illustrate this point by one or two perfectly familiar examples. The discovery of the circulation of the blood by Harvey was assuredly a most important, and has usually been considered a most fundamental, contribution to physiology. It blew to the winds a multitude of vague fancies and vitalistic conceptions, and so illuminated this great function that down to this very hour every lecturer on physiology describes the circulation essentially as Harvey described it, as a circulation carried on on ordinary hydraulic principles through the action of a central pump, the heart. Yet the solution of Harvey's problem, fundamental though it seems, immediately presents us with another, much more subtle, much more elusive, viz., what it is that happens in the tissue of the heart which causes it to beat. As you are aware, that is a problem which is at this very moment engaging the most active attention. In order to attempt its solution with a prospect of success, physiologists have felt constrained to subdivide it, and to ask first of all whether the cause of the rhythmical beat of the heart resides in the nervous structures or in the muscular fibers of the cardiac wall. I need not go into the history of the discussion which has arisen over this question. For a quarter of a century or more numerous workers have labored at the task. I do not wish to seem to prejudge a question which is still pending. But it seems probable that the outcome of the controversy will be to establish the cause of the automatic beat in the muscular fibers of the heart. Here again, however, there is no finality. The question immediately arises, and a far more fundamental question it is than any of those which have preceded it, why do those muscular fibers spontaneously contract? What is it that takes place in them when they beat, and which stimulates them as we say to this contraction? It is obvious that light may be thrown upon this ques-

tion by investigating the conditions which favor or hinder the rhythmical beat. Much of the most brilliant work in this regard has been done here in Chicago, by Professor Loeb and his pupils. They have shown that certain inorganic ions (sodium ions *par excellence*) have an intimate and peculiar relation to the beat, and that it will not take place if these be absent. This at once raises the question whether the sodium ions are necessary in order that the stimulus to contraction may be discharged, or in order that, the stimulus being given, the muscle should be able to respond to it. And the observation of Overton, published the other day, that sodium chloride is peculiarly necessary for the excitability of skeletal muscle may perhaps be taken as indicating that the sodium ions are also necessary for the excitability of heart muscle, whether necessary or not for the discharge of the stimulus. It is clear that this at once suggests the query, how far the processes occurring in the cardiac muscle resemble those occurring in skeletal muscle. We can probably conclude that during the actual contraction the processes are very much the same in both. And this brings up the question (I am not, of course, attempting to follow the historic development of the subject) what the changes are that take place in muscular tissue in general when it contracts. To this question we can give the answer that certain chemical and electrical changes are associated with the contraction. And this in its turn lands us in the problem of the connection of these changes with the mechanical changes in the muscle. The precise relation of the electrical changes to the contraction is still undecided. As regards the chemical changes, we have advanced so far as to be quite sure that the energy of the contracting muscle is derived from the combustion (or the splitting) of certain substances in the muscular fiber. But here for the present we come to a full stop, with the question in front of us, how the muscle by burning these substances is able to alter its form in such a remarkable manner. If we could solve that question fully we should probably be very near a solution of the general problem of physiology.

Let us take another illustration. During the sixteenth and the seventeenth centuries the whole of medicine was under the sway of the iatro-chemists, a set of extremely theoretical gentlemen who decided that everything, *nolens volens*, must be explained on chemical theories. Ferments were invented without the least proof of their existence to explain the most recondite phenomena, and spirits were invented to

direct the work of the ferments. According to Van Helmont the Archæus, a remarkable spirit of quite democratic tastes and not at all above culinary pursuits, gives his personal attention very largely to the function of digestion.

These vague notions lingered till the discovery by Spallanzani, Beaumont, and many others of the fact that the action of the gastric juice and other digestive secretions is a chemical one which can be exerted outside the body as well as in the alimentary canal, and with the establishment of this fact the whole fantastic fabric of the medieval physiology of digestion came clattering to the ground. We have now, thanks to the work of numerous observers and in recent years particularly of Pawlow and his school, a very fair knowledge of how the digestive juices act on food substances and even of how the nature of the food modifies the character of the digestive juices. But when we ask ourselves how the digestive juices are themselves formed, we are again at the end of our tether. We know that the pancreatic juice is secreted, as we call it, by the pancreas, that the gastric juice is secreted by the gastric glands, and so on. But we do not at all know how it is that from the same liquid, the blood or the lymph, the gastric cells form pepsin and hydrochloric acid, while the pancreatic cells form an alkaline secretion with perfectly different properties. And it is obvious that, just as in the case of the muscular contraction, as soon as we penetrate beyond the envelope and ask what happens in the substance of the fiber itself, by what subtle mechanism there is produced so strange, so almost startling a phenomenon as contraction, so in the case of the gland as soon as we penetrate to the boundary of the individual cell and ask by what subtle chemistry such remarkable results as the separation of an acid from the alkaline blood, in the case of the gastric juice, or a liquid with a freezing point of $-1.5°$ C. from blood serum whose freezing-point is about $-0.6°$ C. in the case of the urine, we are aware that we again stand in the presence of the question on what the peculiar properties of living substance depend, in other words in the presence of the general problem of physiology.

This then is what I say, that no matter from what standpoint you set out, no matter what special research you take up, no matter what particular organ you investigate, muscle, nerve, organs of special sense, tissues of digestion, mechanisms of reproduction, elephant or bacterium, a man's brain or a blade of grass, if you push your enquiries you always

arrive at questions which can only be settled by a knowledge of the physico-chemical constitution of living matter. And from this I draw the conclusion that all physiological problems are important as regards the development of the science if only they are studied from the proper standpoint, and that all the methods which are useful for the study of particular problems are, if intelligently employed, methods which are either capable of throwing light on the general problem or of aiding in its definition. But the study must have a definite end in view. A well-thought-out program with a question propounded to which a definite answer in one direction or the other can be given (still better if the answer be a quantitative one), a definite use of methods for the attainment of this answer, and a proper apprehension of the relations of the answer to other ascertained facts, these qualities are of the essence of true research. I have heard the story told that a new professor appointed to the chair of physiology in a famous European university where at the time the necessity for research was not very clearly recognized, after getting his laboratory in working order and teaching begun, bethought himself that it would be appropriate to start some experiments. He therefore consulted with a young member of his staff as to what the research should be, and after much communing they determined that it should be a research on a rabbit. I need not say that a research on a rabbit is no research at all. Mere fumbling about a laboratory in the hope that one may strike upon something new is very different from true investigation.

Reasons for the Choice of a Particular Problem.—While it is true that any problem, if followed into all its consequences, is important because it brings us at last face to face with fundamental problems, there are of course at any given stage in the development of a science certain questions or certain lines of work which possess a peculiar interest and importance in themselves. Very often it happens that the development of the sciences most immediately accessory to physiology, anatomy, physics and chemistry, places in our hands knowledge or methods which determine the most promising direction of physiological investigation at any particular time. The mere mental fermentation which a striking advance in any one science engenders in the minds of workers in other sciences is apt to give them a bias in a particular direction, sometimes with favorable, but at other times it must be said with unfavorable, results, on the development of their own proper studies. If we study the

history of physiology nothing will strike us more forcibly than the fact that at different epochs it has presented very different aspects. And often the transformation from one predominant aspect to another has been due to such a stimulus from without as I have alluded to. The great discoveries of the Italian anatomists after the Renaissance made physiology anatomical. The separation of the body into organs of different function became its prime task. The genius of Descartes gave it a mechanical aspect. The appearance of the new chemistry was the signal for the subjection of physiological as well as medical science to the sway of the iatro-chemists. The iatro-mathematical school succeeded the iatro-chemical. It flourished especially in England, where the contemporaries of Newton were fired with the idea of explaining all the actions of the body in health and disease by the new mathematics. In the first part of the nineteenth century the note became predominantly physical, when Hering measured the circulation time and Volkmann the linear velocity of the blood, when Ludwig introduced the modern methods for measuring blood pressure, and Helmholtz analyzed the vowel sounds and made his great contributions to physiological optics, and when du Bois-Reymond expanded electrophysiology into a science. As the nineteenth century grew older the aspect of physiology became more and more chemical, this change being stimulated especially by the advance of organic chemistry. And now the prevailing aspect is changing again to the physical-chemical, owing to the great development of molecular physics and physical chemistry.

In the science of physiology, as in most others, there is another reason which often confers importance upon a question, sometimes out of proportion to its intrinsic value if considered merely in relation to the development of the science. I suppose there may be some physiologists, a very, very few, I believe, to whom the fact that their science has a practical value to mankind is positively distasteful, just as there are said to be pure mathematicians who devoutly pray that their achievements in the world of symbols may be of no use to anybody. But I confess that to me, and I do not doubt to the vast majority of my brother physiologists (although they assuredly will not go so far as Bacon, who says in the "Novum Organum" that "the real and legitimate goal of the sciences is the endowment of human life with new inventions and riches"), it is a cherished thought that our science is

and must ever be one of the chief cornerstones of practical medicine. It is a dear and a cherished thought that while all our labor is tending surely to the increase of our knowledge of man and of his relations to the world around him, not a little, and indeed an increasing proportion of our work is being practically applied to the alleviation, the cure or the prevention of disease, to secure for the toiler in the factory and the mine, for the salesgirl in the store, and for the sailor in his ship, for the soldier in his barracks, ay, and for the prisoner in his cell, to secure for the child in the schoolroom, the playground and the home, the conditions needed for healthy life and work and for physiological development.

Some Important Special Problems.—I pass now to the consideration of some of the more important special problems. Among the most important of the present-day problems of physiology, in my opinion, is the influence of ions on the life phenomena and therefore on the living substance of cells. It would be like carrying coals to Newcastle were I to dilate upon this theme in the University of Chicago, which the work in the physiological laboratory on the effect of ions upon the absorption of water by muscles, on the rôle of ions in chemotropic phenomena, and their influence upon the development of eggs, fertilized and unfertilized, has rendered one of the greatest centers of physiological research in this country. Such experiments are calculated to throw a flood of light upon the physico-chemical constitution of living matter.

But it is becoming increasingly clear that to understand the cell we must not only study the influence of substances of all kinds on the cytoplasm and the nucleus once they have passed through the cell-envelope and the nuclear membrane, but we must study the nature of these envelopes, their permeability for various bodies, the relations of this permeability to their physico-chemical constitution, and the alterations which it undergoes under various conditions. Since I have a personal interest in this phase of the subject I may perhaps be pardoned for speaking of it in some little detail.

More than five years ago, starting from the experimental fact that the colored corpuscles of the blood, as well as pus corpuscles and lymphocytes, have an extremely low electrical conductivity in comparison with the serum, a circumstance which is due to the relatively small permeability of the envelope of the corpuscles for the ions of the

serum and for the ions in the corpuscles themselves or for some of these, I ventured on the generalization that the envelopes of all cells are relatively impermeable to the ions of the liquids with which they are in contact and to the free ions present in the cell contents. I reached this conclusion partly on the general ground that there is in many cases at any rate a marked difference in the inorganic constituents of the cells and the surrounding liquids, an argument which Overton has quite recently emphasized in the case of striped muscle. I further argued that the well-known fact that the apparent transverse resistance of nerve is much greater than the longitudinal resistance, receives a natural explanation on the assumption that the nerve fibers are surrounded by badly conducting envelopes. In addition I pointed out that the phenomena of polarization, including the electrotonic currents both of medullated and of non-medullated nerve fibers, as well as other electrical phenomena both of nerve and muscle, with the alterations produced in them by the death of the tissue, could also be explained by the presence of a badly conducting envelope. I then stated a general line of research in the following words, "Assuming then for the present without attempting to give formal proof of the assumption that in general the cells of the animal body are bounded by an envelope relatively impermeable to the ions of the extra- and intra-cellular liquids, it becomes of interest to determine the degree of permeability of the envelope for as many different kinds of cells as possible and for as many different substances as possible," and in particular the conditions under which this permeability is altered. Since that time the greater portion of such leisure as I have been able to snatch from the all-devouring maw of professional routine has been devoted to this inquiry, and results have been obtained which seem to set in a clearer light the peculiar relations of these envelopes, these peripheral layers, these frontier films, if you will, to the contents of the cell, on the one hand, and to the extracellular liquids with which the cell is in contact and with which it traffics, on the other.

With regard to other tissues than those free cells I have already mentioned the circumstances which render it extremely probable that similar envelopes of low permeability surround the contractile substance of muscle and the conducting substance of nerve. Quite recently Macdonald has published an important paper in which he brings forward strong evidence that the current of rest in nerves may be

thus explained. Bernstein, only a few weeks ago, has adduced reasons founded on the change which the electromotive force of the current of rest of muscle and nerve undergoes as the temperature is altered, for the conclusion that this current is what is called a "concentration current," *i. e.*, is due to the physical process of diffusion and not to a chemical process. The production of such a concentration current can be explained either on the alteration theory by the formation at the cross section of an organic electrolyte whose ions have different velocities in the fiber and sheath, or on the membrane theory with the aid of electrolytes (mainly inorganic salts) preexisting in the fibers or fibrils, under the assumption that the living plasma membranes (what we call envelopes) of the fibers or fibrils are impermeable or with difficulty permeable for one or both ions. Strong has also elaborated a theory which seeks to explain both the current of rest and the negative variation as due to the core-model structure of the nerve. And Boruttau with a core-model consisting of gelatine cylinders of potassium chloride solution surrounded by a mantle of 0.6 per cent. sodium chloride solution has actually reproduced certain of the electrical phenomena of nerve, and believes that all of the electrical phenomena of active nerve, including the action current, can be explained by its properties as a core-conductor. On this hypothesis the peculiar permeability of the envelope for electrolytes must necessarily play an important part in the conduction of the nerve impulse.

As a matter of fact, too, in all work on the action of ions on the living substance the influence of the permeability of the cell envelope has to be taken into account. Thus it is perfectly possible that the presence of ions of one kind may prevent the entrance of ions of another kind into a cell. In this case what might look like an antagonistic action of two kinds of ions on the protoplasm might in reality be due merely to an altered permeability of the membrane. For example, the action of calcium in neutralizing the ill effects of chlorine ions on the heart muscle might be due to a diminished permeability of the envelopes of the muscular fibers to the chlorine ions, produced by the calcium ions. I need hardly remark that although the cardiac muscular fibers have no sarcolemma I still conceive of them as possessing a physiological envelope.

It is to be hoped that the further study of the permeability of the envelopes of different kinds of cells may throw light on their selective

powers. I have shown, for example, that the relatively great permeability of the red corpuscles for ammonium chloride as compared with sodium chloride depends not upon their life, but upon their structure, and that it is not abolished by fixing with formaldehyde. The action on the envelopes and cell substance of bodies which are lytic for particular kinds of cells, for example, hæmolytic agents (chemical and biological) in the case of blood corpuscles, and the specific lysins in the case of other cells, is also a promising field of research. In this connection the discovery of the so-called specific precipitins has raised a host of interesting questions. It may be said in a general way that if we inject repeatedly into the peritoneal cavity of an animal of a given species, the blood of another species, the serum of the first animal will produce a precipitate in the blood of any animal of the second species, but not in the blood of an animal of a third species. For example, if a rabbit be injected with human blood, its serum will cause a precipitate in human blood, but not in the blood of a dog or a cat. According to Grünbaum's observations, however, a precipitate indistinguishable by the ordinary method of procedure from that obtained with human blood is given by the rabbit's serum with the blood of the anthropoid apes. Such results throw a vivid light on blood relationship and give a biological meaning to the term which could hardly have been anticipated. It need scarcely be pointed out that a reaction of this kind, if perfected and rendered sharper and more delicate, might even aid the zoologist in the grouping of animals.

Another line of work which seems hopeful is the investigation of the so-called colloid solution. Considering the hæmoglobin in the colored corpuscles as probably in a state of colloid solution, I made a study of the action of laking agents in causing intraglobular crystallization in *Necturus* corpuscles and obtained what seem to be rather suggestive results. It is possible that investigation of the influence of ions on this phenomenon might throw light upon the colloid condition and upon the circumstances under which the equilibrium is upset.

In a word, the whole subject of the chemistry and physical chemistry of cells presents an attractive field. A great elaboration of microchemical methods is much to be desired.

Then again there is the problem of absorption from the alimentary canal, and the relations of osmosis and other physical processes to it; there is the problem of secretion, and the investigation of specific

stimuli to secretion like the newly discovered body secretin, which is formed in the mucous membrane of the intestine when hydrochloric acid comes into contact with it, and which, passing to the pancreas by the blood stream, excites a copious flow of pancreatic juice. The suggested gaseous secretion in the lungs is certainly worthy of further study. A more minute investigation of the action of secretory nerves is required. Numerous problems connected with the formation of lymph are still awaiting solution.

Nor in spite of the enormous amount of work which has been devoted to metabolism is there any sign that we have done more than approach the threshold of the subject. The mechanism of the oxidations and reductions occurring in the body, the origin and action of the group of oxidizing ferments known as oxydases, and indeed of ferments in general, including those concerned in intra-cellular digestion of proteids and the phenomenon known as self-digestion or autolysis of the organs, the steps by which protoplasm is built up and decomposed, all these topics are brimful of problems. We much need what we may call cyto-metabolic studies, which will teach us in what parts of the cell particular steps of metabolism are conducted. Lillie, for example, has shown that the nucleus is a special seat of oxidation.

Then there are the comparatively new fields of internal secretion, the defensive, adaptive and regulative chemical mechanisms of the body, chemotaxis, and the world-old problem of heredity. Our ignorance of the chemical and physical changes associated with the functions of the central nervous system is practically complete.

While I indicate these as promising lines of research I recognize very well that none of the older fields is exhausted. We still need much information on the mere anatomy of the nervous mechanisms that control the heart, the blood vessels and the respiratory muscles, especially as regards the afferent paths. The fact announced by Bayliss within the past year that all the vaso-dilators of the hind limb and intestines (in the dog) run in the posterior roots and are therefore not efferent fibers in the morphological sense, but afferent fibers conducting nerve impulses in a direction opposite to the ordinary (anti-dromic nerve impulses as he calls them), the revolution which the work of Pawlow and his pupils has wrought in our knowledge of the action of the digestive juices on the food and on each other, the investigations of Sherrington and Grünbaum on the motor areas of the anthropoid

apes, which have excluded the ascending parietal convolution from a place in the motor region which it had occupied undisturbed for more than twenty-five years—these few instances out of many which might be quoted should warn us that there is still rich browsing on the ancient pastures of physiology.

Methods.—Much of what I have said of the problems is true also of the methods of physiology. All good methods are of use. And just as the predominant aspect of the science at a particular time determines problems, so it determines methods. For certain problems some of the old methods are very good and some of the new ones very bad. For other problems the old methods are useless. There is a very old method, the oldest, I suppose, of all physiological methods, which consists in simply doing something to a structure and then looking and seeing whether your interference has produced any effect. This is the method of inspection, and in the hands of Langley it has yielded brilliant results in the elucidation of the paths and functions of the various kinds of fibers in the sympathetic system. For other inquiries special instruments, as plethysmographs, cardiographs, sphygmographs, erogographs, spectroscopes, calorimeters, and so on, and special ways of using them, must be employed.

I should be sorry to jeer at such classical objects and instruments of research as "the frog and the myograph, the dog and the kymograph." I believe they are invaluable for particular purposes. But there are a thousand questions to which all the muscle tracings and all the blood-pressure tracings in the world will never return an answer, and yet you may get an answer by the methods of chemical analysis. Then there are numerous problems, and those among the most fundamental which you will never settle with the balance and burette, and which may yet be solved by the galvanometer, the electrometer, or the new methods of physical chemistry. And then again there are many problems for the solution of which we may have to wait long till appropriate methods are developed for their attack. Contrariwise, new methods will not unfrequently suggest new problems.

If I were to indicate any particular group of methods which seem to have the promise of the future I should be inclined to lay stress upon the methods of physics and of physical chemistry. Of all sciences physics, "the great mother of the sciences," to use Bacon's phrase, is the most indispensable to the physiologist. Mathematics, as being insepa-

rably intertwined with physics and physical chemistry, is also of importance, although at present its field of application is much more limited in physiology than in physics because our science is at present much less a quantitative one than physics.

I do not know whether I ought to include it among the methods, but I can not help thinking that perhaps the most important method of all is the *organization of our researches.* By this I mean that not only should the individual worker so plan his work that he will most easily and surely arrive at his goal, that not only should the head of a laboratory take thought to preserve a unity of plan and a common impulse in the work which he directs, but that something like a scientific clearing-house might be devised by which coordination of work should be brought about between the active laboratories of a country at least, but perhaps in time of the world. I hope indeed the time will come and I think it will come, although perhaps not for a while, when, all the world over, a drilled army of workers shall devote their energies to investigation under competent leadership. Think of the time and strength now in too many cases frittered away because every man is working in his own corner. Think of the waste in the duplication of perfectly established results, the secrecy, the heartburnings, the jealousy and bickerings for priority which that secrecy engenders. Under a proper system numerous zealous men whose labors are now in great part lost, because through inexperience or lack of knowledge they attack unsuitable problems or attack suitable problems in a wrong way, would be so guided and inspired by others of larger experience that the cumulative effect of their work might be great.

In conclusion let me say that quite as important as the choice and the statement of a problem, quite as important as the choice and the evolution of methods for its solution, is the mental and I may almost say the moral attitude of the investigator toward his task. It may seem superfluous to remark that he must be entirely willing to learn the truth, the whole truth and nothing but the truth. But man is naturally an obscurantist. The human mind is far less open to new truth than is sometimes supposed. There is in the back of the minds of most of us a desire to preserve or to accept beliefs that are pleasant and flattering. Now it is unfortunately the case that it is pleasant and flattering to the investigator to find that his new facts seem to fit in with his old theories or with facts which he has previously discovered. And to

nearly every one of us a fact that we expect to find is more welcome than the gaunt exception which refuses to be covered by our theory and whose rebellious angles threaten to distort the sleek contours of our general law. Yet as Claude Bernard has well said, "It is precisely the exceptional fact which is valuable, for it is by following it we shall discover new truth, if a discovery is to be made." Let me remind you how for long years the doctrine of phlogiston, phantom of the brain as we now know it to have been, held sway over the minds of acute and truth-seeking men, who in every combustion must needs detect the entrance or the exit of phlogiston; and how in our own profession men believed it to be as sure as any scientific fact can be that copious bloodletting was beneficial in pneumonia. Read Sir Thomas Watson's charming lectures on physic, and you will see that this was not the belief of ignorant quacks, but of men quite as acute, quite as well up in the science of their time as any of your contemporaries. All this should teach us humility, that humility which according to Faraday, the greatest experimental physicist of his day and one of the humblest-minded of men, should be the first and the last step of education. At the same time, there is a scientific use of the imagination which is sometimes of the utmost value in unraveling the complexity of things and which no one employed more boldly than did Faraday himself. If I may be allowed to paraphrase a favorite remark of Sir Henry Lawrence, the hero of Lucknow, "that it is the due admixture of romance and reality which best carries a man through life," I would say that it is the due admixture of imagination and self-criticism which constitutes the most valuable ingredient in the mental outfit of the physiologist.

One word more and I have done. I do not like to prophesy. It is a dangerous habit. But you will see, I think, that there lies ahead of us in physiology a period of active and fruitful expansion. There will be no lack of problems in our day. The goal of physiology and medical research is still infinitely distant, for with every new advance new prospects open, new questions suggest themselves in a series that seems endless. To the physiologist, of course, as to other men the question comes at times with crushing force, "What profit is there in all our labor that we do under the sun?" When we thus falter in the march, baffled by that subtlety, that obscurity of things of which Bacon speaks so frequently in the "Novum Organum," we may find comfort in the thought that every fragment of real work is bringing nearer for man

the day of knowledge and therefore the day of power. Some day perhaps the mystery of life and being which presses on the physiologist as on other men, and indeed with a double weight, may be solved. Some time perhaps man may know not only what he is, but why he is. To-day, after but three thousand years of history and three hundred of science, it is indeed difficult to imagine how this can be. We can only trust that it may be. Some far-off to-morrow may arrive when the clearer vision of a million years of science and of history may fathom the secret and read the reconcilement of the hopes and the destiny of man.

> "A hair, they say, divides the false and true;
> Yes; and a single Alif were the clue,
> Could you but find it, to the Treasure-house,
> And peradventure to the Master too."

ON THE IMPROVEMENT OF MEDICAL TEACHING[1]

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The watchword of the present is conservation. Especially in the industrial world it has been shown that great improvement is possible by the elimination of needless waste of time and energy. Though not yet so clearly recognized, this is equally true in the field of education. Teachers, especially those in the higher institutions of learning, are notoriously neglectful of the principles and technique of their profession. Unquestionably this results in great losses due to inefficient methods of teaching. These losses, in medical education, may be conservatively estimated at twenty to twenty-five per cent. In other words, the adoption of more efficient methods of teaching would probably enable us to gain the equivalent of a whole year within the time now devoted to the four years' curriculum. Is not the possibility of such a tremendous saving well worth our serious consideration?

At the outset, it should be clearly understood that *uniform* methods of teaching are neither necessary nor desirable. The methods in detail must be determined by the individual teacher to meet best the varying local conditions. But equally true is the important fact that all efficient methods of teaching must be based upon well-known and well-established principles of pedagogy. Efficient teaching requires three essential conditions: (1) complete mastery of the subject-matter on the part of the teacher; (2) a clear notion of the aim of the teaching; and (3) well-chosen methods of accomplishing the aim. The first and most essential condition, that the teacher must be a master of his subject, is everywhere clearly recognized, and will not be discussed in the present paper. The second and third conditions are those oftenest overlooked, and it is therefore necessary to emphasize certain fundamental principles of aim and methods, the neglect of which is largely responsible for inefficient teaching.

[1] Read at the twenty-second annual meeting of the Association of American Medical Colleges, Chicago, February 28, 1912. Published in *Science*, N. S., Vol. XXXV., No. 902, pp. 566–571, April 12, 1912.

In the first place, let us therefore consider the aim of medical education. In this all will probably agree that the *primary* aim of medical education should be to train efficient practitioners.[2] And it may furthermore be taken for granted that an efficient practitioner is one who is able to observe accurately, to think clearly and to act wisely in his medical practise.

Keeping in view this primary aim and ultimate purpose of medical education, to train efficient practitioners, we may next consider the methods, the ways and means, whereby this aim is to be accomplished. If the end is to be reached most directly, if the student is to be trained most economically for the greatest efficiency, it is evident that the instruction must be adapted to his nature and learning capacity. How shall this be done? Let us see whether there is any rational principle to guide us in adapting our methods to the nature of the student. Upon this question an important light is thrown by the history of education.

A century ago, practically all teaching was based upon the doctrine of authority. It was the function of the teacher to *tell* the student what he should know and do. It was the duty of the student to be a passive recipient, to follow faithfully the precepts of the teacher. This doctrine of authority, however, was found inefficient and has long since been abandoned in rational education. It is now generally recognized that all education really worth while is based upon *self-activity*. This principle, advanced by Froebel, is now so thoroughly established in education that it may almost be taken as self-evident. Self-activity is the keynote of modern pedagogy. And yet, while recognized in theory, this fundamental principle is often almost totally neglected in practise. In the light of this principle of education by self-activity let us review briefly certain phases of methods in medical teaching.

In developing the self-activity of the student, it is evident that the methods first of all must arouse his interest and attention. Interest we know to be most intense in things which satisfy conscious needs. Now the medical student wants above all to be a good practitioner. If he knows that a certain thing will help him to accomplish this, he is intensely interested, and will exert an active effort to secure it. "The mind interprets impressions from without, not according to their

[2] In addition to the education of practitioners, the medical school has other important functions, such as the advancement of medical science through original investigation, but these are not within the scope of the present paper.

intrinsic nature, but according to their relation to the needs of the organism" (Bagley). Common sense and good pedagogy therefore agree that in teaching any subject in the medical curriculum, the teacher should make sure that the student realizes its bearing upon his later work.

Some may conclude from the foregoing that, since time is limited, only the so-called "practical" facts, those that are of obvious utility in the practise of medicine, should be taught, and that no time should be wasted on "theoretical" aspects. While this argument may appear plausible at first glance, its fallacy is apparent on closer examination. In the first place, it is impossible in any given subject to select out only those facts which may later be needed. Moreover, even if such facts could be selected, it would be impossible to teach them as bare, empirical facts, in such a way that the student could understand, remember and utilize them, without a comprehension of the science of which they form a part. The "theoretical," as Bagley states,

> contributes to the coherence of the various facts and principles as *knowledge*. Its value can not be disputed, for any attempt to "cut out" the "impractical" parts invariably results in the inefficient functioning of the remainder. Short courses that give only the essentials, fifth-rate colleges and normal schools that educate you while you wait, are sufficiently damned by their own products.

There is, it must be acknowledged, some truth in both the "practical" and the "theoretical" points of view. The best methods of teaching will, therefore, utilize both. While each subject should be taught from the theoretical, scientific point of view, at the same time its practical application should be kept constantly in mind. In selecting material to develop the essential principles, those facts should be chosen which will also probably be of greatest intrinsic value for later work. Anatomy, for example, should be taught, not as a mass of empirical facts, but as a special branch of biological science. But in selecting from the huge mass of available data the facts necessary to illustrate the science of anatomy, so far as possible those facts should be chosen that are also of direct, intrinsic value in physiology, pathology and clinical medicine.

If this plan were consistently followed out, and everything excluded excepting facts, especially those of intrinsic value, necessary to develop a scientific basis, a "working-knowledge," for each branch of study, the amount of subject-matter presented in each could be greatly reduced. We all recognize that the curriculum is now overloaded. It is

impossible to teach so much and teach it well. "What men need" (according to Huxley) "is as much knowledge as they can assimilate and organize into a train for action."

To develop in accordance with the foregoing plan the most effective methods of teaching, it is evident that each teacher must understand the curriculum as a whole. The laboratory man must be familiar with the clinical work. But this is not all. Since good teaching must take into account that which has gone before as well as that which is to follow, it is equally evident that the clinical man must be familiar with laboratory subjects and methods. We can not expect the best results in medical education until there is a better understanding and more cooperation between teachers of the various subjects all along the line. As medicine progresses, all phases appear more clearly as varied manifestations of the same underlying biological science, and only when this is realized will the clinical and laboratory work be more closely knitted together.

We have seen that to interest the student and arouse him to self-activity, he should be made to realize that each subject contributes an essential part in training him for the desired end. We may next inquire as to *how* he must be self-active. Since efficiency in practise consists in accurate observation and reasoning, resulting in wise action in dealing with medical problems, his training should develop self-activity in these very lines. He must observe, think and act for himself. For this purpose almost ideal facilities exist in our laboratories and clinics. Unfortunately, however, we are far from utilizing these facilities to their fullest extent. Our methods fail to make the student self-active, especially in observation and reasoning.

First we may consider observation. This can be cultivated only by actual observation of medical phenomena on the part of the student. It is, however, a surprising fact that in many laboratories and clinics there is no opportunity for the student to make an *original* observation. Why? Simply because through a pernicious lecture system he has already been told all about what he is to see, before he has ever had a chance to observe it for himself.

It is furthermore a fundamental law of learning (technically the doctrine of apperception) that we can not comprehend new facts except upon the basis and in terms of previous concrete experience. Hence the dictum: "In teaching, always proceed from the concrete to the

abstract; from the particular to the general; from the known to the unknown." It is therefore evident that to give lectures preceding practical objective study not only prevents the exercise of original observation, but also inverts the normal procedure in the process of learning.

Much time and energy is sometimes thus wasted in trying to teach by lectures what would be quickly and easily comprehended *after* the fundamental data had been acquired by objective study. In some schools, for example, the junior year is largely given over to lectures and other didactic work which is supposed to prepare the students for the actual clinical work, the latter being chiefly concentrated in the senior year. This, it seems to me, is a fundamental mistake. If there were only one alternative, it would be better to reverse this order, giving the clinics first, and the lectures later. In actual practise, however, they are best intermingled and closely correlated, care being taken always to provide the objective basis before the more abstract generalizations are considered.

Even when the practical work is placed first, however, it by no means follows that adequate training in observation will result. In both laboratories and clinics it is a common practise as a preliminary step to *tell* the student (either orally or by printed guides) what he is to see. The student thus is not required, and indeed has no opportunity, to observe for himself. Practically all there is left for him to do is to verify what he has already been told. However valuable this may be, it does *not* develop power of original observation. It is, of course, desirable to precede all practical work with a brief introduction which will enable the student to proceed intelligently with his work. Such an introduction, however, should be merely for the purpose of explaining technical procedure and of raising questions the answer to which the student should seek by original observation.

The ideal plan is thus for the student to work out everything for himself by the method of discovery. This applies not only to the original observations, but also to the later process of reasoning, whereby we proceed from particular data to general conclusions, and thence to rational action. The method of self-activity may therefore be expressed in a negative way by the following practical rules: Never tell a student anything he can observe for himself; never draw a conclusion or solve a problem which he can be led to reason out for himself; and never do anything for him that he can do for himself.

Unfortunately, however, there are limitations to the application of this method. It is difficult to apply successfully, requiring skill and experienced judgment on the part of the teacher. Lack of time would moreover prevent the student from repeating the history of the race by the method of discovery. But though difficult and slow at first, by working out for himself at least the fundamental data, a solid basis is laid which makes possible more rapid progress later. Time lost at the beginning is thus time gained in the end. We should therefore insist that *so far as practicable* this ideal method be applied for the purpose of training the student to self-activity, in developing his ability in observation, reasoning and action.

As supplementary to the foregoing, it is usually necessary to adopt easier though less effective methods of instruction. Thus where necessary data can not be secured by original observation, they may be supplied by the usual type of laboratory or clinical demonstrations, which the student can verify. Next in value below this as a means of imparting knowledge comes the informal lecture or recitation, illustrated by demonstrations, models, pictures, etc. Next comes the text-book, and lowest of all in the scale is the formal lecture. Curiously enough, the lecture is also the *easiest* method, by which *apparently* the greatest amount of information is gained with the least expenditure of energy, at least on the part of the student. But this is a delusion. The knowledge thus gained is unreal and transient. It is "in at one ear, and out at the other." As we should naturally expect from the principle of self-activity, the ease of the method is apt to be inversely proportional to the efficiency of the instruction. In order therefore to train our students most efficiently in self-activity, we should use the maximum amount of the more difficult but more effective methods and the minimum of those easier but relatively inefficient.

This will perhaps be made clearer by a brief illustration from personal experience. To learn, for example, the normal histology of any given organ by means of a stained and mounted section, this should first be studied by *original observation*. The students observe the structure with naked eye, low power and high power of the microscope, and without previous description by teacher, book or laboratory outline. They record their observations by sketches and brief notes. The aid of the teacher at this stage should be restricted to questioning the individual students so as to recall related facts previously studied and pre-

vent the student from going too far astray. At first, students are apt to be utterly helpless when thus thrown largely upon their own resources, but they soon develop surprising powers of observation. This "investigation" occupies the first part of the laboratory period. The teacher then informs the class regarding the section they have studied, and discusses briefly their mistakes of observation. He directs them in restudying the section, and in correcting their mistakes. The students now extend their knowledge by verifying the statements found in their text-books. Demonstrations are made to furnish additional data and elucidate the more difficult points. Drawings are finally made by the students, to fix the corrected impressions upon their minds. At a later class-conference, the students are led to review the facts learned, to correlate and interpret them and to reason out general conclusions or laws of structure. These laws they utilize and apply in the subsequent work. Brief written reviews are also frequently held. Occasional lectures by the teacher elucidate the more difficult phases, and indicate the relations of histology to physiology, pathology and clinical medicine. The results are satisfactory as shown by final examination, both written and practical, and by the extent to which the students are able to retain and utilize their knowledge in later work.

The foregoing method illustrates how students may be trained to self-activity in observation and reasoning, and to a certain extent in application. The application of the generalizations reached by observation plus reasoning, while essential in every subject, is especially characteristic of the clinical work. That the student should be self-active in his clinical work, that to acquire skill in the practical application of his previous knowledge he must "learn by doing," is universally recognized. It is therefore unnecessary to dwell upon this phase of the subject. It may be worth while, however, to remember that, above all, in the clinics, "the main business of the teacher is to render his services unnecessary" (Strayer).

To summarize the foregoing: it has been maintained that in medical education there is great need of more effective methods of teaching. Efficient teaching requires a clear view of the ultimate aim, which in medicine is to train efficient practitioners. To accomplish this aim, rational methods of teaching should develop in the student self-activity in observation, reasoning and action. While some may be unable to accept fully the ideas here presented, all will surely agree that great

improvement would result if medical teachers would study more carefully their educational methods. The younger teachers who are so fortunately located could greatly improve their efficiency by taking work in the schools of education connected with the various universities. Those unable to do this should at least study the principles of pedagogy, which are available in numerous books. Although pedagogical literature deals chiefly with elementary, rather than advanced or professional education, it is nevertheless of great service, for the same fundamental principles extend throughout, from the kindergarten to the university. Among those books which may be recommended as helpful are the following: Spencer, "Essays on Education" (a recent edition, with introduction by ex-President Eliot, in the "Everyman's Library" series); James, "Talks to Teachers on Psychology," etc. (Holt); Charters, "Methods of Teaching Developed from a Functional Standpoint" (Row, Peterson & Co.); Bagley, "The Educative Process" (Macmillan); Thorndike, "The Principles of Teaching Based on Psychology" (Seiler). And in conclusion, permit me to suggest that a more thorough discussion of educational methods and principles in our association meetings, and also in the faculty meetings of our various medical schools, would result in greater efficiency in our teaching.

EQUIPMENT AND INSTRUCTION OF THE LABORATORY YEARS[1]

By E. P. Lyon, Ph.D., M.D.,

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Before attempting to discuss the subject set before us, it may be well if we agree as to the function of a medical school, and as to the aim of all of us who devote our lives to medical education. In an address last year, Dr. Welch[2] said that our object is "to make good doctors." Professor Minot[3] in his Washington University commencement address, gives a more exact formulation in these words: "The chief function of a medical school is to produce practitioners." Whichever definition we prefer, we doubtless agree on the main idea; and I ask you, therefore, to bear in mind that our purpose is to make or produce something, and that something is a good doctor or practitioner.

The making of something implies five factors: (1) raw material; (2) a model or pattern (which of course may be either substantial or existing as an ideal in the mind of the workman); (3) men to do the work; (4) a place to work in and tools to work with; (5) time to do the work. The results may be bad from failure in any of these points.

Our frequent considerations of entrance requirements and qualifications of students show our interest in raw material. Our time-consuming studies of curriculum and equipment give evidence that we are concerned with tools and place of work. Our occasional weak efforts to determine who are qualified instructors indicate our interest in workmen. Our discussions of four-year, five-year and six-year courses reveal our recognition of the time factor. While our very discordant ideas as to what constitutes a "good doctor" show how little we have considered the model or pattern in our educational manufacturing establishment.

What Constitutes a "Good Doctor"?

What is a "good doctor"? Is he that lovable figure of the "Bonny Briar Bush," "Old Chester Stories" and other contemporaneous fiction?

[1] Published in the *American Medical Association Bulletin*, January 15, 1911.

[2] *Proceedings Association of American Medical Colleges*, 1910, p. 62.

[3] *Journal American Medical Association*, 1909, Vol. LIII., p. 502.

I am sure most of you would say "No." Is he the hermit of the test-tube, incubator and centrifuge? Being that kind of a hermit, I will save you the trouble by answering "No." Is he the physician (too often found in medical faculties) of extensive clinical training, who ridicules the laboratory and says the microscope has no place in medicine? Some of you will reply in the negative. Is he that ignorant but *honest* man found so often as the legally constituted physician of an ignorant community? Or is he the equally ignorant but *dishonest* individual who, with or without legal right, is the physician of people less ignorant than himself? We are all agreed that the "good doctor" is neither he "who knows not that he knows not," nor he who veneers his ignorance with an assumption of knowledge. But we can not agree exactly what a "good doctor" is. Some will say "Practical"; some will say "Scientific." Some will say "Knowledge"; some will say "Heart."

In proposing to discuss the topic assigned to me from the standpoint of the pattern or model, I shall not attempt, therefore, the task of formulating in words all the qualities of a "good doctor." Some of them fortunately are on the surface and do not need a psychologist's analysis nor a philosopher's logic, nor a novelist's rhetoric.

An Accurate Observer

First: the "good doctor" must be an accurate observer. His senses must be trained and alert. Eye, ear and finger must be sensitive and connected with a brain which is quick to recognize and discriminate. Dr. Minot, in the paper already quoted from, has discussed this matter fully and convincingly. He points out the difficulties and limitations of accurate observation; some of them connected with our imperfect sense organs; most of them, with our imperfect mental processes. We can not go into detail here, but the upshot of the matter is that the good observer is partly born and partly made. The former moiety belongs to our raw material and need not be considered here. The latter is of immediate interest, for we know that the power of observation can be cultivated. It improves by practise. Next in importance is skilled direction or instruction.

All of the studies of the fundamental years are suited to develop observation. Anatomy more than the others is adapted to this end. In my judgment its presence in the curriculum is chiefly justifiable on this account, rather than from its supposed practical value. Anatomy is

concerned with a great variety of complex structures, whose materials, textures, forms, sizes and relationships constitute observational material of the most alluring variety and complexity. Moreover, the student always feels that the subject is of practical importance, and this adds an element of interest on the part of the learner which gives to anatomy a value for the training of observation even greater than that afforded by its peculiar material and methods.

Value of Cross Sections

I feel that for the purpose we are discussing, namely, the developing of powers of accurate observation, the study of cross sections of the body is of greater value than dissection. No doubt each supplements the other, but the study of structures from section to section with their variations, appearances, disappearances and relations must be of great influence in stimulating the power to visualize or, as some anatomist has put it, to see the body as if it were transparent, a power so necessary to the physician and surgeon and so impossible of acquisition except on the basis of accurate observation in the anatomical laboratory.

Like gross anatomy, microscopic anatomy in its various divisions, such as histology and embryology, is chiefly an observational science. Here we introduce the use of instruments of precision as an aid to observation. The microscope is of the utmost importance, not on account of the immediate facts revealed, valuable though these are; nor on account of its use in diagnosis, indispensable though this should be; but chiefly because of the relation in which it places the observer with respect to the objective world. The space sensations connected with binocular vision and accommodation do not help him. The third dimension can only partially be supplied by focusing. If he is to get any idea of solidity and relationship, he must be able to visualize. He must add field to field and place section upon section *in his mind*. If I may parody an old adage, he must mix his seeing with brains. Indeed the mental effort must here be inevitably the larger part of observation. Microscopic anatomy is justified on this basis if no other.

Careful Work Essential

If now it is true that anatomy is chiefly to be considered as an aid to the development of accurate observation, we immediately see the futility of hasty and careless dissection and of short perfunctory courses

in histology. They defeat the very end for which these studies should be undertaken by substituting hazy impression for accurate observation; carelessness and error for thoroughness and truth.

What is true of anatomy in the above respect is true of every other science so far as the development of observational power is concerned. I think, therefore, that we have a scientific basis for the belief that it is not number of facts that we should attempt to demonstrate, but rather perfect observation and understanding of a few. Nor should we favor a multiplicity of short courses of study. Intensity and accuracy should be our watchwords, rather than breadth and general impression. If one is turned rapidly in a circle, a thousand images flash across the retina, yet one sees nothing. It is those images that are dwelt on and repeated and studied that remain and strengthen our powers and become a part of ourselves.

Full-time Instructors Essential

If it be true that observing power is a chief characteristic of the "good doctor," and if it be true that anatomy constitutes an excellent and probably the best training for acquiring this power, and if it be true that particular instruction and supervision are necessary, then it is perfectly evident that proper regard for the product of our educational establishment will make us provide expert workmen in gross and microscopic anatomy. If a man knows what to see in the human body, how to see it and how to bring others to see it, he has enough to keep him busy. He has no time to become competent in another trade or profession. He can not drive a street car nor conduct a real-estate business nor practise medicine. Hence, we have the argument, from the standpoint of a good "output," for the anatomist who shall give his whole time to the medical school.

Essential Equipment and Assistants

The same arguments that make necessary the professional anatomist make equally indispensable (1) a proper place for him to work, which means not only teaching laboratories, but also research rooms; (2) proper material for teaching and study, which means cadavers, microscopic preparations, embryos, animals, etc.; (3) proper equipment, which means microscopes, microtomes, models, photographic and projection apparatus, books, periodicals, etc.; (4) proper help, which means janitor service, technician, artist, etc. (on the universally acknowledged economic principle that it does not pay to have a high-priced man do low-class work).

We are driven by all the foregoing to conclude that an institution is failing in its regard for its "output,"—for its "model," the "good doctor,"—when it fails properly to provide for the anatomical sciences.

The "Good Doctor" a Trained Experimenter

Besides being an exact observer, the "good doctor" must be, in my opinion, a trained experimenter. In regard to this statement there may be diversity of opinion. When I read it first to my wife, she said, "What I want is a doctor who *knows*. Let him experiment on other people. I want him to have his experimenting all done when he comes to me." Doubtless this expresses very well the general attitude of the lay mind; and this attitude may be responsible for the ultra conservatism of medicine. The doctor is afraid of being accused of experimenting with his patients. Nevertheless he is always doing so; and in the present lack of knowledge he must experiment, at least in treatment, whether he wishes to or not. I should perhaps add that by experiment I do not mean the use of some new drug or surgical procedure. If the physician tries the effect of rest, or baths, or gymnastics, or deprivation of coffee, it is just as truly an experiment as a first injection of salvarsan.

The main difference between experimentation and ordinary observation is that, in the former, the observer controls and varies the conditions. The primary element of observation is just as important as ever, but the equally important element of controlled conditions is added. The mental process is by that addition made more complex. The results, moreover, are more fruitful than those of simple observation, since the experimenter can bring under observation conditions which nature might never produce.

I have said that every "good doctor" should be a trained experimenter. I believe that very few are such. Most physicians do not know how to experiment. Their methods are at fault. Consequently their conclusions are of little value.

Principles of Experimentation

The first principle of experimentation is to vary but one factor at a time. If a physiologist is studying the effect of load on muscular contraction, he does not, at the same time that he changes the load, also change the temperature and the stimulus and the speed of the recording apparatus. But I have seen a physician make all the following changes

at one time: (*a*) put a patient in bed, (*b*) restrict his diet, (*c*) give a saline cathartic, (*d*) give some drug. Then he concludes that the patient's changed condition is due to the drug. This may be true, but the conclusion is not warranted from the experiment.

The second principle of experimentation is repetition. There may be an unrecognized factor. Therefore, no conclusion can be of general application unless the experiment is repeated many times with like results. Of course this is the method of inductive logic in general; but I have frequently heard physicians remark: "I never use so and so. I tried it *once* and it didn't give good results." This is absurd.

The third principle of experimentation is that the results to be of most value must be quantitative. The practising physician has hardly made a beginning in the use of this principle.

The Experimental Sciences

The sciences which are preeminently experimental are physics, chemistry, physiology, pharmacology and bacteriology. Each of these, like anatomy, makes a large demand for pure observation and is valuable for developing that power. In addition, each asks for experiment. Their general principles are alike, but each has a technic of its own. Physics lends itself more easily to the quantitative method. Chemistry and bacteriology furnish valuable aids to diagnosis, but are distinctively *in vitro* as to method. Physiology and pharmacology, on account of their use of living material for experimental purposes, come especially close to medicine, not only in subject-matter but also in method.

What I have said regarding observation and anatomy applies equally well to experimentation and to the sciences just mentioned. If the "good doctor" should be an experimenter, surely as a student he must learn to experiment. Learning is by doing. He must learn under those who know how to experiment and how to teach that art. This argument leads inevitably to the professional bacteriologist, chemist, physiologist, pharmacologist. Only that man who is specially trained in one of these sciences, who has done and is doing research in it and who is devoting his whole time to it can teach it to the best advantage.

The same arguments as formerly made also apply regarding equipment and facilities. A chemical laboratory with a place and apparatus and material for each student and rooms and equipment for the staff; physiological and pharmacological equipment and laboratories for stu-

dents and staff; an animal house and living material; technicians and janitors (again on the basis that an institution or factory or railroad is unwise which compels a five-thousand-dollar man to do the work which a five-hundred-dollar man can do as well or better); bacteriological equipment including proper space, instruments and materials for the use of instructors and students; books and periodicals, and places to keep and use them,—all these must be provided if the institution has a proper regard for its output, a "good doctor."

A "Good Doctor" Must Reach Accurate Conclusions

To the powers of observation and experimentation the "good doctor" must add that of sound conclusion or correct interpretation or good judgment. This means the bringing of facts together and the determination of relationships. It means the recognition of cause and effect. Doubtless the psychologist would further subdivide the mental functions involved. But for our purpose the above will suffice.

Now, it is evident that you can not make a sound conclusion without the facts, and these are gained by observation, with or without experiment. It is equally evident that an isolated fact is barren and dead. Facts are like the cells of a complex animal, all interrelated, mutually affecting and affected. The hormones or internal secretions constitute a fitting metaphor for those relationships which the power of correlation discovers between the isolated results of observation and experiment.

Training Value of Pathology

All scientific studies tend to develop this power of interpretative judgment, but not all to the same extent. The dynamic sciences, such as physiology, are more valuable than the static sciences such as anatomy. But perhaps the best for the purpose, at least so far as the making of doctors is concerned, is pathology. At any rate, I have reserved this science to illustrate this phase of my thought.

Here we have a pathological condition. The normal appearance, structure, relation, should be such and such. It should function so and so. How and why did this change come about, and what and how far-reaching may be its results? The entire keyboard of observational science, almost, may here be played upon: Physics, chemistry, zoology, botany, anatomy, histology, physiology, bacteriology. And just as in music the harmony or dissonance depends on how the notes are chosen

and blended, so the soundness or unsoundness of conclusions depends on how well facts have been determined and how truthfully their relations have been perceived.

Wholly apart, then, from the significant facts which it presents,—in other words, its subject-matter,—pathology is justified in our curriculum on account of the training it affords in one of the indispensable mental qualities of the "good doctor." The doctor without sound judgment, which means without the power of scientific deduction, is indeed a very *bad* doctor. You catch again the drift of my argument. We must supply a professional pathologist who shall devote his best efforts, in conjunction with those other scientists already mentioned, to building up the students' mental machinery for orderly and logical reasoning.

Just as in the former cases, here also, while the man is of first importance, he can not do good work without proper surroundings and proper equipment. You must not only furnish the pathological laboratory and library, but also, and more important, you must secure such hospital connections as will guarantee ample autopsies and supplies of material for gross and microscopic study. You must give the pathologist proper help for the best conduct of his department. You are not having proper regard for your "model" or your output, the "good doctor," if you disregard these important matters.

Fundamental Sciences Sources of Power

So far I have considered three traits of a properly trained medical practitioner, power of observation, ability to experiment and sound judgment. I have attempted to prove that the fundamental sciences, wholly apart from their subject-matter, are justified in the medical curriculum as sources of power. I have tried to show that they must be taught by professional scientists and not by practising physicians. I have pointed out that proper laboratories and equipment must be provided, and that to curtail your departments in material and help is narrow business policy. There are a few practical conclusions from these premises which I wish now to present.

Need of the Research Professor

If the sciences are to be taught for power rather than subject-matter, we have, as I have said, the unanswerable argument for the research pro-

fessor in charge of each scientific department. He alone thoroughly understands the scientific method. How absurd, if this is true, is that frequent arrangement in which the professor lectures and the untrained or half-trained assistants conduct the laboratory work! Laboratory instruction conducted from the standpoint of scientific method is the most difficult form of teaching. Too often, as Dewey[4] well says, laboratory practise becomes purely ritualistic; such and such forms to go through; such and such demonstrations of manual dexterity to be secured. This degeneration of laboratory teaching is due largely to that laxity and short-sightedness which permit its being turned over to secondary instructors. Better by far, if either must be done, is it to have the assistant give the lectures and the professor the laboratory instruction, rather than the reverse.

Essential Laboratories

Secondly, I have spoken of student laboratories. A little reflection shows that these are of four kinds, each concerned with a different material and provided with a different type of equipment. The first is concerned with the human cadaver. The equipment is simple and for a variety of reasons the rooms must be restricted to the one use only. The second type of laboratory is adapted to chemical experimentation. The requirements of heat, water, numerous reagent bottles and considerable individual equipment, as well as the unavoidable fumes and waste products, make it inadvisable to use this laboratory for any other purpose than the teaching of chemistry. The third type of laboratory centers around the use of the microscope. Appropriate tables, abundant light, and individual microscopes are indispensable. The same room may serve for microscopic anatomy and pathology and, with some additional equipment, for bacteriology. The fourth type of laboratory is adapted to physiologic experimentation. It may also be used for pharmacology.

Good Teachers vs. Fine Buildings

A medical school which has four good laboratories for students' use should spend its superfluous cash on men rather than buildings. I have no sympathy with that condition which I recently saw in one of our great medical schools where six magnificent laboratories are used only three mornings or three afternoons a week for four months of the year.

[4] *Science*, January 28, 1910, Vol. XXXI., p. 121.

I admit the advantages of good architecture and fire-proof construction and modern ventilation, but I contend that in some places departmental pride and too abundant funds have led to a multiplication of laboratories which is not justifiable. That all the ideas of industrial efficiency can not properly be applied to universities is readily recognized, but every new building means more money for maintenance and less for men. In our line of business, to use a slang expression, the man is the "whole works," which is really but another way of saying "teacher at one end of a log and student at the other." One log will do for several teachers, if used at different times of the day or different days of the week or different months of the year.

Thirdly, regarding equipment, if proper instructors are secured, you can leave the details to them. You remember the advertisement of the house-furnishing concern, "You get the girl, we will do the rest." The medical school may well be advised to get the man and he will do the rest. Getting the man, too, is as serious a matter for the school as getting the bride is for the swain for whom the advertisement was originally intended.

It was once remarked that, if you give Jacques Loeb a collar box and a piece of string, he will make a discovery. On the other hand, I know a man who three years ago could not do any work because his Edinger apparatus had not come; two years ago he was waiting for material from Java; last year he found he needed a dark stage illuminator and a micropolariscope. Now he is waiting for a new laboratory building. These extremes illustrate the man and equipment proposition better than many paragraphs of theory.

Teachers more Important than Equipment

For our friends the state boards we may respectfully suggest that they spend more time in trying to find out whether the medical schools are properly manned, and less in making lists of apparatus which may or may not be used. I once tramped to the top floor of our medical college in order to demonstrate to an inspector that we have a perimeter; and when I showed it to him in a case with other instruments, I am willing to take oath that he was either cross-eyed or else he looked at the wrong thing. This same man did not ask how many paid professors we have, nor what their training and experience have been, nor whether we are doing any original work, nor what the annual budget is. But he

did inquire what we were doing with those dogs in a medical school. And he did naïvely remark when I showed him the pathological outfit: "Ah, your chemist is in charge of this work?"

Most humiliating of all—but whether for me or him I know not—was his inquiry after consulting his typewritten list whether we had a "bakoscope." I took a glance at the list to make sure I had heard rightly. It was there, "Bakoscope"; and unwilling to admit that I didn't know of such an instrument, I regretfully confessed that we did not have one. I think the investigator took some satisfaction in noting this fact on his report. It was not until some days later that it dawned upon me that this probably should have read "phakoscope." But of course my native modesty, up to this time, has prevented my informing the gentleman of this supposition. For the information of certain captious individuals I should, perhaps, add that the inspector in question was not Mr. Flexner nor Dr. Colwell.

The Doctor's Influence

Coming back now to my main theme, it seems to me that the qualities of accurate observation, correct experimentation and logical conclusion are the ones which the doctor must depend on for success in the practical part of his profession. They are the attributes of a good technician. But the doctor is more than a technician. He stands in the most intimate private relation to his patients. The nature of his work contributes to his influence on the social order. Other men in their professional and business life are apart from society. Only in their leisure hours are they affecting the life of other people, and then not intimately. The doctor's influence is always being exerted, and is always direct and potent.

The "Good Doctor" a Man of Character

Now, the psychological qualities bearing on this side of the doctor's life are many and varied. Professor Minot[5] considers that loyalty is the trait which is most essential. But I prefer to join all the qualities of loyalty, sympathy, promptness, honesty, discretion, firmness and many more into the one quality—character. We are agreed that the good doctor must be a man of character. Now character, like everything else, seems partly hereditary and partly acquired. The hereditary element,

[5] *Journal American Medical Association*, 1909, Vol. LIII., p. 502.

as also the early acquired, concerns our raw material. We are justified in rejecting and must reject any applicants who give evidence of defective character. That is, however, a hard problem and not for discussion to-day. The question here is, what can we do for the upbuilding of character in the medical school? I take it that this is a most serious question. Under our control and direction come a multitude of young men, many of them just from their homes for the first time and all of them pointed toward a profession whose influence reaches the very fountains of human life. We can not, if we would, avoid responsibility for the character of these men.

But how can we influence them? They are at that age when the unfettered soul dips into life in all directions; that age whose impelling powers determine lines of progress for a lifetime; that age which examines and tests and questions all things whether material or intellectual. You can not do much with these men by talk. A preacher in a medical school would need the rarest tact not to be worse than useless. I take it that our young men are influenced most by those whom they admire. These they imitate unconsciously.

The Best Teacher a Man of Character

The point I am driving at is that your medical teacher must be a man of character. He must be a man to whom young men will be attracted and whom they may safely imitate. The scientific attitude of mind with its rigid adherence to truth supplies a basic condition of character; and that is why professional scientists and the scientific atmosphere are especially influential on the character of medical students. But other things are necessary. I would not have a teacher who is habitually profane. Not merely because profanity is wicked, but because it does not conduce to the "good doctor." I would not have a man whose lectures are chiefly or even partially made up of coarse stories. I would not have as an instructor in a medical school a doctor who all the time emphasizes the financial aspects of his profession.

My thesis is that character is the *sine qua non* of the "good doctor," and that the principal way we can influence the medical student, who is a doctor in the making, is by surrounding him with characters worthy of imitation. Consequently, the character of a medical teacher is a matter for the gravest consideration. Unless you take cognizance of this you are not having regard for your output, a "good doctor."

Recapitulation

To recapitulate, we as medical teachers are engaged in manufacturing. Our product is doctors, and they ought to be "good doctors." A "good doctor" is a man of character, who possesses the technical qualifications for accurate observation, properly conducted experimentation and sound interpretation. For the acquisition of the traits mentioned no discipline is better than that furnished by the fundamental medical sciences. The sciences therefore should be taught as method rather than as subject matter.

We must furnish for this purpose skilled professionals; in other words, investigators. We must give them places for work; that is, laboratories. We must furnish equipment; that is, tools and books. We must select good raw material and leave it in the hands of the workmen long enough to enable them to produce good goods. If we do not do these things, we are not conducting an honest business. Our product is a cheap and deceptive imitation. Our graduate is a counterfeit, and we have not even the counterfeiter's excuse that we need the money, for there is no longer any money to be made in medical education.

THE EDUCATIONAL FUNCTION OF HOSPITALS AND THE HOSPITAL YEAR[1]

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THE central figure in every hospital is, or should be, the patient. Whatever use is made of the hospital as a means of education it should be self-understood that whenever the sick man enters its walls he has a right to expect and demand the most skilled treatment its staff can offer. We physicians believe that the best treatment will be in the hospital that clearly recognizes its educational function. But if the patient be utilized for the instruction of nurses, undergraduate or graduate medical students, or in the working out of some scientific problem, there must be assurance that his life is not endangered thereby or his health impaired. We may use him as "material," to employ the word that unfortunately has become fixed in our medical vernacular, but not as we use a Wheatstone bridge, a burette, a test tube, a guinea-pig or rabbit. We claim that it is our right and duty to experiment with inanimate apparatus, and—when we are humane—with the lower animate bodies, even though the test tube break or the rabbit die. But a human being is neither a test tube nor a guinea-pig. We may study his disease, even experimentally, but we must treat *him* as a fellow man.

A modern hospital fully awake to its privileges and with the high aim to do the greatest possible amount of good will strive to educate: (1) Undergraduates; (2) internes, graduate or undergraduate; (3) resident physicians and surgeons; (4) the attending staff; (5) nurses; (6) research workers; (7) the patient; (8) the public.

1. UNDERGRADUATE INSTRUCTION

Undergraduate medical instruction can best be carried on in a hospital founded primarily for educational purposes, and especially one under the immediate control of a medical school. The student's presence in the ward is not looked on as an intrusion or as due to favoring condescension on the part of the hospital authorities. He is there by

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right; he makes examinations, acts as clerk in recording changes in the patient from day to day, is laboratory assistant, etc. And yet he is without authority to prescribe for or to treat the patient. He makes no promiscuous examinations. He is watched and guided and does no harm. He follows the case during the course of the illness. A student carefully observing and studying even a small number of cases of illness, even though the maladies be simple, compelled to keep complete records that are scrutinized daily by his superior, has learned more of correct methods and of practise, perhaps more even of fact, than from hours and hours of lectures.

In the majority of our public hospitals the lax methods, the multitude of students, the prejudice against the use of the patient as "material," the politician's fear of criticism, the failure to provide capable and responsible supervision, make students' ward work very unsatisfactory or wholly impossible. Much is often accomplished by means of small-group clinics with the student at the bedside as the case is demonstrated, or by ward walks as in England. And much is done by the arena clinic, no longer popular as of old, but by no means entirely out of date, and still fulfilling a useful though subordinate purpose.

2. Instruction of Interns

Of the value of an internship in a good hospital, where in addition to the student's clerical and laboratory work there is actual responsibility, usually a graded responsibility, *i. e.*, one increasing with his length of service, there is no question. No one who has had the advantage of such a training doubts its value; no one who has not had it but regrets his inability to secure it. The eager competition among our raw graduates for these positions shows the estimate placed upon them by our student body.

Sooner or later some period of training—say a year—in a hospital should be required of every student before he becomes a licentiate in medicine. If the time is ripe it should be demanded now. We must command the support of the public in this advance by making them see that if the young graduate does not gain his practical experience in a hospital under the guidance of older heads and in an atmosphere redolent of traditional medical knowledge handed down from one generation of interns to another and from one group of attending men to another—and this traditional knowledge is one of the most valuable assets of a

hospital—if he does not get his training in this safeguarded manner before he is a licensed practitioner he is forced to get it in his private practise, on your child or on mine and with no counseling voice of senior to keep him from sins of omission or commission.

The marvel is that so many men with utter lack of hospital training are able to go out and do so well—*i. e.*, do so little harm. Native shrewdness, earnest endeavor, tact, ability to learn quickly from others and from their own mistakes, enable them to succeed in a wonderful manner. How many sad, even fatal, blunders are made through lack of proper practical training no one can tell—it is best not to tell. Even the celebrated Dr. San Grado wished Gil Blas to go about with him for a few days on his rounds of bleeding and drenching his patients with water before the said Gil Blas was to be permitted to practise as the representative of San Grado.

The difficulties in the way of a required fifth hospital year are not insurmountable. More internships must be available to accommodate our large annual output of doctors or the number of graduates lessened. Why not both? If the efforts made by this association are successful the number of graduates in medicine will be diminished. But the number of hospitals will increase; and many small hospitals now working without interns—and there are large ones, too, in this same condition—will see that it is impossible to get along satisfactorily without these assistants and so more places will be available. But there is another difficulty, and to my mind by no means an insignificant one. How are these hospitals to be standardized? In general the work of the staff and of the intern, in a hospital with medical college affiliation, is up to the standard of the medical school itself, yet not always. The small medical school with the large hospital at its command can take care of its own graduates and place them as interns. But what about the large medical school with a small hospital? Its graduates must be placed in other, perhaps remote, hospitals. Now there will have to be a good deal of educating of some hospital boards of management and of many medical staffs, taking hospitals as they run, before we can declare that an internship in some of these hospitals meets anything like satisfactory requirements. Many small hospitals and many large ones with no medical school attachment would readily be conceded as up to grade. But in many hospitals, some small, some large, some in the small towns and some in the large cities, the intern does little more than give an anes-

thetic, dress and take the blame for the pus cases, and occasionally examine the urine or sputum. No histories or none worthy the name, no laboratory tests, no thorough examination of a patient. The intern gains a certain amount of self-confidence, often an unwarranted amount which is largely absorbed from the staff, though there is seldom any appreciable loss at the source of supply; he learns not to faint at the sight of blood, learns the dose of a good many drugs, some of which he might well forget, and he learns that an easy, a lazy, substitute for thinking is to do an exploratory laparotomy. Such training is superficial, incomplete and in many respects pernicious. The medical school with a high standard for both entrance and graduation must pause before committing itself to a policy of a compulsory hospital year until there is in sight a sufficient number of places in good hospitals where work will be up to grade and where by virtue of authority to inspect and supervise there may be a guaranty that it will be kept up to grade and satisfactory to the college and to the officials of the state. Before a compulsory fifth year is added to our college requirements for graduation a certain standard for hospitals must be fixed and means taken to sustain the same.

3. Educating Resident Physicians and Surgeons

The older I grow and the more I see of surgery, the more convinced I am that the mere holding of the degree M.D., as at present granted, ought not to entitle a man to do surgical operations, at least major operations. The lack of manual dexterity and celerity, the poor judgment as to how much can and ought to be attempted in a given case, the puttering and hesitating due to insufficient self-confidence and to a fear of supposed dangers, or the equally horrible condition of over-confidence and lack of dread, how keenly do all these shortcomings, the result of limited or no practical training, loom up before us when we contemplate an operation to be done on our friend or some member of our own family by one of these poorly qualified young graduates. No surgery, no major surgery at least, no special surgery, until he has tried it first on the dogs! no surgery until as assistant, and perhaps resident, he has for a given time stood at the left and then at the right hand of the surgeon and has himself, with the help of this surgeon, done operations. When the good, honest family practitioner tells you he is convinced that surgical treatment of appendicitis is wrong, because, of his operative

cases, three out of four died, including clean cases operated on in the interval, and says that he shall return to the medical treatment which gave him better results, we agree that it is wise for *him* to treat appendicitis medically. But the smile that comes to our faces as we note the delicious humor of his innocent condemnation of self as a surgeon is turned to a sober frown as we realize the pathos and tragedy of the clean cases. Make surgery more of a specialty if you will; let there be fewer surgeons in a given area if necessary; divide the fee—openly—if necessary; but insure more expert work by requiring a special hospital training before the graver operations are attempted. Our hospitals can here do a splendid educational work by giving opportunities to residents and assistants working under the responsible guidance of the older man.

4. Educating the Attending Staff

Of the value of the hospital experience to the member of the staff there is little need to speak. Every physician and surgeon admits freely that the faithful performance of his hospital duties makes him a broader, more careful, more skillful man. There is only one point in this connection that I would emphasize, and that is that those hospitals in which there is a distinct teaching feature will have the best service from the staff especially in the case of the poorer and charity patients. Nothing so arouses the physician to do his best, to study his patient so thoroughly, as the knowledge that that case of illness has to be demonstrated at short range to a class of keen-eyed students. A few bad blunders before a class are all that is necessary to make him more careful next time. And then the rubbing of elbows with our colleagues, the activating influence as the older man is inoculated with the enthusiasm of the young man of the staff, just back from Europe, perhaps; all this is helpful and educational.

5. Educating Nurses

It is not my purpose to dwell on the function of the hospital as a training school for nurses. Its duty in this respect is becoming more generally recognized and the advantages that accrue to the hospital, the patient, the physician, the public, are too well known to be repeated here.

6. Educating Research Workers

The spirit of research has reached many of our hospitals. Some have been founded with the primary object of promoting research along medi-

cal lines. It is to be hoped more will be liberally endowed so that this highest grade of work may be carried on with the closest possible union between laboratories, as they are commonly termed, and the wards that are also really laboratories. While it is not possible that all our hospitals should be *sensu strictiori* research hospitals, while it is not desirable that they should all be of this character, there should be more of the spirit of investigation and reaching out for new truth in our existing hospitals, even those that are utilized for the instruction of undergraduates, interns, residents and attending staff. Unless the spirit of research be in such a hospital and pervade its various staffs, the educational function languishes and the hospital atmosphere is stale. To be progressive, research must be carried on. It may be in trying out methods advocated by others or devising new and better ones; it may be along lines of therapy, surgical or medical; it may be studying the refinements of diagnosis or the natural history of disease, or in the chemical, bacteriologic or anatomical questions concerned in disease; it may be searching for results that are of immediate practical application or working on problems in pure science where no practical bearing is in sight, but something of this sort must be carried on by the hospital workers or a hospital is not doing its duty in furthering knowledge. And I am of the opinion that our hospitals will be utilized more and more for research work in sociologic problems. There is a rich field for such investigation in many of our wards.

7. Educating the Patients

Much might be said of the help our hospitals may bring to their patients in teaching lessons of obedience to authority, consideration for and cooperation with one's neighbors, etc. Lessons of cleanliness and of hygiene are also taught, and surely certain lessons in morality are inculcated in ways as effective as any pulpit eloquence. But this is not the time or place for discussing this topic.

8. Educating the Public

Nor is this the place to speak of the opportunity many of our hospitals have of educating the public as to matters of personal and public health. By example, by class and lecture work, by literature, by letting the hospital light not be hidden under a bushel, such an institution may be a power for good in the community and be the means of combating

the effects of many foolish or even harmful "isms" and "pathies" that are everywhere to be found.

Summary

To summarize these points which have consciously been merely touched on and not dealt with exhaustively—an impossibility in a twenty-minute paper:

It is the privilege and duty of hospitals to extend their field of usefulness by opening their wards more freely to undergraduates in medicine, to elevate the standards of work done by nurses, interns, residents and attending staff, to foster research. By so doing they are not harming the patient, but are rather insuring him better and more skilled treatment. They are serving to enlighten and educate not only the individual, but the observing lay public as well, eager to learn and to be instructed in knowledge of medical matters.

And what concerns us as physicians looking to the elevation of the standards of medical education is that so soon as possible each medical school should have its own hospital where the wards are freely utilizable for the instruction of undergraduates, where a definite service in practical work in medicine and surgery shall be demanded as a prerequisite for graduation, where assistants and residents may be in training for specialties in medicine and surgery and where the spirit of investigation and research pervades every worker from the probationer nurse to the chief of the attending staff.

Until such medical school hospitals are obtained the aim should be to secure similar privileges in other good hospitals, seeing to it that some authoritative supervisional check may be had on the character of work that is there done before credit is given in the medical school for such undergraduate or intern hospital service.

THE ADDITION OF A FIFTH YEAR TO THE MEDICAL CURRICULUM[1]

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The remarkable advance in medical education in the last quarter century has concerned both the kind and the amount of the training demanded of the medical student. Laboratory and practical courses, in which the students, in small groups, are brought into immediate contact with the materials to be studied, and thus obtain knowledge at first hand, have largely supplanted the didactic lecture and recitation, especially in the fundamental branches. Unfortunately, the introduction of similar methods—of objective teaching—in the clinical subjects has made little progress, excepting in a few schools, and the lamentable deficiency of our medical students in practical experience at the bedside is keenly realized. How serious and deplorable is this deficiency has been graphically set forth by Mr. Flexner, of the Carnegie Foundation, in his Report on Medical Education.

The amount of education demanded has been increased at two points—the extent of preparation exacted for admission to the medical school, and the length of time required to be spent therein. As the successive steps in advance have been taken, the decision as to where the increase should be made has not always been wise. When, for example, about fifteen years ago, a general increase was made in the curriculum from three to four annual sessions, it would have been better if, in lieu of this, the advance had been in the premedical requirement, this requirement being at that time in most schools, about two years of high-school work, rather loosely enforced. Much more would have been accomplished in the direction of elevating the standards of the medical profession had the emphasis been placed at that time on a fairly adequate preparation for medical study.

Fortunately, during the last five or six years, rapid progress has

[1] Read before the meeting of the Association of American Medical Colleges, Chicago, February 28, 1912. Published in the *Journal of the American Medical Association*, August 24, 1912.

been made in this direction, and with about thirty medical colleges now exacting two years of college work for admission, with five of the state boards of medical examiners demanding the same as a prerequisite for licensure, it seems pretty certain that this will be the uniform standard of the medical schools, in the northern states at least, within the next decade. With the present conditions in most of the secondary schools, and while so large a proportion of students enter college at twenty-one or older, and the medical school at twenty-four or later, it seems unwise to contemplate any further advance in the requirements for admission to the medical schools, as a universal standard, in the near future. Nothing less than this, however, will suffice to give the student adequate preparation for the study of medicine under existing conditions. One year of college work is not enough to afford the requisite training in English, mathematics, physics, chemistry, biology and foreign languages, notwithstanding the fact that the Council on Medical Education of the American Medical Association has recommended such a curriculum of one year.

If the premedical curriculum may be regarded as satisfactorily determined for the present, the next step in advance in medical education, at once the most needed, and, under the right conditions, the most feasible, is the addition of a fifth or practical year to the present course of study, this year to consist of service as an intern in a hospital, under supervision of the faculty or, in exceptional cases, for those who look forward to a career of teaching and investigation, of advanced and research work in one or more departments of the college. This fifth year should precede the conferring of the degree.

The feeling is universal among medical educators that medical graduates are entering into practise with too meager first-hand knowledge of disease—such knowledge as can only be gained by actual experience, at the bedside under careful supervision. In the earlier years of medical education in the United States, such experience was secured by an apprenticeship with a preceptor. This, indeed, constituted the sole means of preparation of a considerable proportion of medical practitioners until well after the middle of the last century. For the remainder, the one or two sessions of medical lectures, of four or five months each, was the incidental rather than the chief part of their training. The rapid development and growing importance of the fundamental medical sciences led to a steady increase in the amount of

time required of the student in the college, while the changing conditions and methods of practise made it more and more difficult for the preceptor to give his student-apprentice effective instruction, and so his function in the training of the student became gradually less, and the title of preceptor merely nominal. The passing of the preceptor, and of the excellent practical training which the student received at his hands, was a real loss in medical education, but one which seems to have been inevitable. Meanwhile the opportunities for practical experience in the hospital have enormously increased. The hospital idea has grown rapidly. The public is becoming educated to the fact that the hospital is the best and most economical place for the sick—medical, surgical or obstetric. Few cities of 15,000 or more inhabitants are to-day without one or more hospitals.

I have sought to ascertain the number of hospitals and of hospital beds in the United States which do, or which should, admit internes and afford them reasonably good opportunities for practical experience. I have taken the following figures from the American Medical Directory, third edition. The data these supplied are not perfect, as many institutions fail to report the number of beds or to indicate clearly the character of the hospital. With the data at hand the hospitals having twenty beds or more may be grouped as follows:

1. Hospitals associated with, and more or less completely controlled by, medical schools; of these there are 104, with 22,365 beds.

2. Hospitals located in cities where medical schools are situated, but not at present controlled by them; of these there are 645, with 73,535 beds.

3. Maternity hospitals, located, with few exceptions, in cities having medical schools; 71, with 4,115 beds.

4. Hospitals, public and semi-public, located in cities not having medical schools; of these there are 1,381, with 82,320 beds.

5. Public hospitals for the insane, of which there are 173, with an aggregate of 183,665 patients.

6. County and state infirmaries; 267, with 30,100 beds.

7. Private hospitals comprising (*a*) those for nervous and mental diseases of which there are 124, with 12,285 beds; and (*b*) those for medical and surgical and special disorders of which there are 90, with 4,990 beds.

8. Hospitals for contagious diseases; there are 59, with 6,795 beds.

9. Hospitals and sanatoriums for tuberculosis; of these there are 266, with 21,550 beds.

10. United States marine, army and military hospitals, of which there are 79, with a total of 8,255 beds.

Each one of these institutions, with the exception of those for the insane and some of the infirmaries for chronic diseases, needs an intern for every twenty or twenty-five beds. Even with our present excessive output of medical graduates each year (at least 50 per cent. in excess of the needs of the country), there should be a vacant internship awaiting every graduate in medicine.

Several of the stronger medical schools report that not only has every graduate from these schools for the last four or five years been able to secure an internship in a good hospital, but the demand for their graduates to fill such positions has exceeded the supply.

In 1906, one medical school added a fifth year to its curriculum, made optional and leading to a *cum laude* degree. Five other schools have since added a fifth year as an optional addition to the course of study, and one, the medical department of the University of Minnesota, now requires this year for graduation. In Germany a practical year has recently been made compulsory and a similar requirement obtains in some other foreign countries. The uniform adoption of a curriculum extending over this hospital year is recommended by the Council on Education of the American Medical Association. Is it feasible? If so what steps are necessary to put it into operation? What regulations should be prescribed in reference to it?

The plan is desirable and practical for the school which is prepared for it and which can secure the necessary hospital connections and control to insure a place, under the right conditions, for all of its students during this intern year. A serious mistake will be made, however, by any medical college which rushes into the scheme hurriedly, just because the idea is "in the air," unless it is able to meet these essentials.

In the first place, no school should add a compulsory fifth year until its entrance requirements have been made equal to those now demanded by the conditions of the time as exemplified by the twenty-nine colleges now exacting two years of college work beyond the high school. One year is not sufficient, and especially will any attempt on the part of the detached medical school to give instruction in the required physics, chemistry, biology and modern languages, be a serious step backward.

The necessity of securing the proper connection with hospitals involves the large question of the relation of the medical school and the hospital—quite the most vital question to-day in medical education in the United States. What should that relation be? It goes without saying that the dispensary and hospital constitute the laboratories for the clinical branches, as do the dissecting-room for anatomy, the morgue for pathology, and the laboratories of physiology, biologic chemistry, pharmacology, histology, embryology and bacteriology for these several sciences. Mr. Flexner says in his report, in reference to control and utilization of the hospital for teaching and research, that the medical school should bear exactly the same relation to the hospital that it bears to these other laboratories. It is obvious, however, that there are very important differences from the nature of the case. The dissecting-room, the morgue and the other fundamental laboratories serve exclusively the purposes of investigation and teaching. There are practically no limitations on the use of their materials for these purposes. The hospital is primarily a place for the care and cure of the sick. Whatever other purposes it may serve, its use, therefore, must always be conditioned on, and subordinate to, that one vital fact—the welfare of the patients. No use of these patients for any purpose can for an instant be tolerated which is in any degree prejudicial to their welfare, entails unnecessary suffering or delays their restoration to health. Moreover, in the long run, it is in the best interest of science, as well as humanity, that no patient should be used as a clinical subject against his will. The use of a pauper patient against his will for instruction or investigation on the theory that he, in this way, makes return for his free treatment, is wrong in principle and pernicious in practise. On the other hand, it is seldom difficult for the tactful, kind physician to secure the consent of a patient, rich or pauper, to serve as a clinical subject.

While the use of the sick for purposes of investigation and instruction must ever be subordinated to their welfare, when conducted under suitable regulations and supervision, such use is not only not inimical to the patient, but decidedly in his best interest. The hospitals where complete and accurate clinical histories are written, where thorough diagnostic methods are carried out by modern methods, in a well-equipped pathologic laboratory, are, almost without exception, hospitals under the control of a high-grade medical school and in which instruc-

tion and research are daily carried on. On this point there is unanimity of opinion by all who are most competent to speak. Says Dr. Keen:

> I speak after an experience of forty years as surgeon to a half-dozen hospitals, and can confidently say that I have never known a single patient injured, or his chances of recovery lessened, by such teaching. Moreover, who will be most slovenly and careless in his duties, he who prescribes in the solitude of the sick-chamber, and operates with two or three assistants only, or he whose every movement is watched by hundreds of eyes alert to detect any false step? I always feel at the Jefferson Hospital as if I were on the run with a pack of lively dogs at my heels.

Miss Barfield, after an ample experience as nurse and patient, speaks as follows:

> As a matter of fact, in a properly administered hospital, medical schools are a protection to the patient rather than otherwise, for it usually means that the hospital is a very live one. In teaching hospitals I think that, on the whole, patients are generally better nursed, for every one is kept up to the mark, including the professors.

And the committee appointed in 1905 to inquire into the financial relations between the hospitals and the medical schools in London says:

> We find that the pressure of a body of eager young men watching the proceedings of their teacher has a tendency to keep the medical men on the alert and to counteract the effects of the daily routine of their duties.

Indeed, the hospital needs association with the medical school quite as much as the college needs the clinical material of the hospital. Hospital boards are beginning to realize this, and some significant demonstrations of this awakening are of recent occurrence. About three years ago the board of directors of a children's hospital, which had been in existence several years, voluntarily sought and entered into affiliation with the faculty of a medical school which had for several years controlled another hospital to the mutual satisfaction and advantage of all concerned. The board asked the faculty of the college to assume entire responsibility for the medical conduct of the hospital; the existing medical staff resigned, and the faculty was given full power to nominate a new staff, which, by the special request of the board, was to include no physician who was not a member of the faculty; clinical instruction and research to be conducted in the wards as directed by the faculty. Within a year another institution has voluntarily sought and secured a similar relation to the same college. These facts are, to my mind, a pretty certain indication of the trend of the times in reference to the relation of existing hospitals and medical schools in some of

the cities of the United States. And does it not offer a more satisfactory and feasible solution of the needs of the medical school for clinical material than does the proposition that the medical school must own and maintain its own hospital?

The hospital being primarily an institution for the care and cure of the sick, its maintenance is not properly a function of the medical school, whose business is specifically educational—including research. In most instances the medical school has come into existence to find the surrounding community already abundantly supplied with hospitals —the evidence of which is furnished by the fact that these hospitals are much of the time clamoring for patients to fill empty beds. True, the conditions in these institutions are usually far from satisfactory, but even so shall the medical college duplicate hospital accommodations already equal to or in excess of the demands of the community, at enormous expense for construction and endowment, or shall it seek to establish the right relations, and secure the necessary control of existing institutions, which control, as has been pointed out, would be to the great advantage of both hospital and school? The great medical schools of European countries, where the control of clinical material is most satisfactory and where the best scientific work has been done, do not as a rule own and maintain hospitals. They use the great municipal or state hospitals maintained by the city or state. The corresponding hospitals in our own country, the management of which, tainted by ward politics, has been up to the present time so unsatisfactory from every point of view, nevertheless contain, and will continue to command, the best possible clinical material, such as no non-public institution can hope to duplicate.

In those rare instances in which a large provision has been made for research, either in the medical school or in an institution devoted solely to scientific investigation, there is advantage in having a relatively small hospital, liberally endowed, in which can be collected groups of cases of this or that disease, primarily for the purpose of an exhaustive and protracted study. Into such institutions patients enter with the express understanding that they are to be made the subjects of investigation—not, of course, to their detriment. Here the purpose of investigation supplants the care and cure of the sick as the primary motive, and the burden of maintenance falls properly on the endowment for research.

It seems to me, therefore, that even for the purpose of securing clinical material for the necessary instruction in the junior and senior years of the present curriculum, the medical school, with rare exceptions, must find it through affiliation with existing or to-be-established hospitals, on a pecuniary foundation distinct from that of the medical school itself, and with persistent and intelligent effort, I believe, this can be done. When it comes to the question of finding places for all of its students in their fifth or intern year, there can be no question about which course the college must pursue. No one, surely, would contemplate the possibility of a medical college undertaking the ownership and maintenance of a hospital of such magnitude as to supply internships to all of its graduates. To supply places for all of its students the students must find places as they are now doing, in detached hospitals, in the cities where the colleges are located, as well as in other cities, more or less distantly removed from the medical schools. It is of course not possible, nor is it necessary, that the medical school should have the same degree of control over the hospital for this purpose as is indispensable for the clinical work of the earlier years, and for the conduct of research by faculty and students. Certain things it must insist on, however, if this fifth year is to be of the largest possible value to the student. The mere securing of an internship in a nondescript hospital, in the perfunctory manner in which it is so often done, does not suffice.

The hospital must have or, not having, must institute a good system of clinical records that the intern may write accurate and thorough case histories.

It must have a well-equipped clinical laboratory convenient to the wards where he may make the necessary examinations of urine, blood, sputum, etc., examine blood cultures, and carry out, in short, all of the approved modern methods of laboratory diagnosis.

Some one or more members of the staff must be able and willing to supervise closely the work of the intern, correct his mistakes, and give him needed instruction in the details of the practise of medicine which he has not yet mastered. These members of the staff will cooperate most cordially and effectively with the faculty if they are made extramural members of the faculty of the school. They should attend faculty meetings as often as possible, and should feel themselves to be an organic part of the teaching body.

It will, of course, be of great advantage if the hospital has a school for nurses, and conducts the nursing work of the institution along approved modern lines. It will greatly enhance the quality of the service rendered by the hospital to its interns, and not less to its patients, if it has a trained, salaried pathologist who gives all or most of his time to the work of the hospital, and who is doing original investigation as are other members of the staff. In time all of these things must be insisted on, but for the present trained nursing and research work are unknown in so many otherwise acceptable hospitals that their general introduction may be secured only in the course of time.

The regulations prescribed by the faculty for the intern should be such as to insure that this hospital year be of the largest possible educational value to the student. The rules drawn up by the faculty of Rush Medical College in 1905 were set forth in a circular announcing the installation of the fifth year leading to the *cum laude* degree. As this announcement may not be without interest in this connection I quote it in full.

FIFTH YEAR

Beginning with the sessions of 1905–6 a fifth year is added to the curriculum, which, for the present, will be optional. The work of this year will be that of

A. Graduate work in one of the departments of the college; or

B. An internship in a hospital.

On the successful completion of this fifth year he will receive the degree of doctor of medicine *cum laude*.

A. The year of graduate work may be taken either

1. In a fellowship, by students who may be appointed to such positions; or

2. As a graduate student.

In either case the candidate must be in residence at least three quarters and complete the equivalent of seven majors of work in some one department, or of nine majors in three or more departments, and present a satisfactory thesis. The candidate must be recommended to the faculty as entitled to the degree by the department in which the graduate work has been done.

B. Fifth year in an internship.

CANDIDATE

1. Every student wishing to take the fifth year as an intern shall announce his intention in writing to the dean of medical students before the last term of the quarter in which he expects to graduate.

2. The internship may be procured by competitive examination or by appointment.

3. Each candidate shall, during his service, be under the frequent and close supervision of a member of the faculty, to be designated as hereinafter provided.

4. He shall make report to this supervising member of the work he is doing,

at least once a month. Such report shall state the number and nature of the cases he has had under his care during the month, and the number of days (if any) that he has been absent from his work, and for what cause.

5. At the end of his year of service he shall submit to his faculty supervisor copies of the complete original histories of at least ten of the cases that have been under his care, and which were written by him, the patients' names to be omitted. These shall be submitted to the committee of examinations for the *cum laude* degree.

6. At the end of his term of service either (*a*) he shall present a typewritten thesis embodying the thorough study of a case or group of cases, including their thorough examination by modern clinical tests, which must be satisfactory to the committee; or (*b*) he shall pass an oral and practical examination before the committee at a time and place to be designated by the committee.

7. He shall be present at the commencement when the degree is conferred; no degree is conferred *in absentia*.

Faculty Supervision

1. During the winter quarter of each year the president of the university, the dean of the faculty and the dean of students, as a committee, shall designate

(A) A committee on examination for the *cum laude* degree consisting of five of the faculty members, selected from at least five of the clinical departments (medicine, surgery and obstetrics to be always represented), who shall serve for the college year, beginning with the succeeding summer quarter; and

(B) Such a number of supervisors as can most conveniently take charge of the work of the candidates for the ensuing year, for the *cum laude* degree by internships. No faculty supervisor shall have charge of more than five candidates.

2. The interns to be thus supervised shall be assigned to the faculty supervisors by the committee on examinations for the *cum laude* degree, as above provided for.

3. It shall be the duty of the faculty supervisor:

(A) To direct and advise the interns under his charge as to the conduct of their work, to the end that it may be of the greatest possible educational value to him or them. Such advice must be so given as in no way to conflict with the desires and authority of the staff of the hospital in which the intern is serving.

(B) He shall receive from the intern a monthly report of his work.

(C) He shall visit, in person, the hospital or hospitals in which the candidates under his supervision are serving, and acquaint himself thoroughly with the physicians of the staff (especially as to their ability and efficiency), with the equipment and the character of its service.

(D) Before the close of the year he shall, with the approval and consent of the staff of the hospital, select from the history-sheets written in regular daily routine by the candidates under his charge, twenty histories taken at random, and shall examine the same carefully.

(E) He shall make inquiry of the attending staff as to whether or not the service of the intern has been satisfactory, and make a report to the committee when the candidate under his charge has completed the necessary period of service, as to the manner in which he performed his duties—whether satisfactorily or otherwise—accompanied by his recommendation as to whether or not the candidate should be given the *cum laude* degree.

HOSPITALS

1. The hospitals in which service as an intern may be considered acceptable for the *cum laude* degree shall be selected by the committee on relations with other institutions, and be approved by the faculty.

2. Such hospitals shall have at least twenty beds.

3. The officials of the hospital shall be notified that such and such persons, whom they have selected as interns, are to perform their services also as candidates for the *cum laude* degree, and the assent of the officials to the arrangement must be secured before the service is entered on.

4. There must be on the staff of such hospital at least one physician who is a member of the faculty of Rush Medical College—either intra- or extra-mural—unless exception be made by the vote of the faculty.

5. A list of the hospitals approved by the faculty shall be kept in the hands of the deans who will advise inquiring students whether any particular hospital is or is not included in the list.

The requirements imposed by these rules were not unreasonable for a *cum laude* degree which, it was planned, should be the equivalent of the master's degree (A.M., or M.S.), conferred by a college or university for one year of graduate work. I am inclined to think that they are somewhat too rigid an exaction, at least in the beginning, for a fifth year which is made a prerequisite for the degree of M.D., and, therefore, for licensure to practise medicine. The amount of routine work now demanded of the intern in many hospitals so consumes his time as to make it very difficult and often impossible for any but the exceptional student to prepare a thesis. This ought not, however, so to be. The intern should have time to study the cases assigned to him thoroughly and carefully, and also pursue exhaustively the study of some disease or condition as presented by some interesting case, or group of cases, to explore the literature relating to that topic, and to set down in orderly fashion the results of his investigation. No instruction or experience in his career as a student of medicine is so potent an educational measure as this one of independent creative work. As previously indicated, I believe it is possible to extend this plan of cooperation and affiliation to hospitals located in cities more or less remote from the medical school. In such case, also, the members of the hospital staffs selected to supervise the work of the intern should be made extramural members of the faculty of the school. Needless to say, no such appointments should be made of physicians simply because they are members of the staff of the hospital. They must be carefully chosen because of their known ability and willingness to instruct the student, and to direct his work carefully, and no hospital should be affiliated

unless there are such persons on its medical staff. In most of the smaller cities such men are to be found, fundamentally as capable of high-grade work, in practise, teaching and research, as are many of the members of the intra-mural faculty. These men would find, in an intimate, vital connection with the medical school and in the work of instructing students, an inspiration and stimulus that would be to their advantage and that they would keenly appreciate. They should visit the medical school from time to time, attend an occasional faculty meeting and become acquainted with its ideals and methods. Their connection with the school should be recognized by the appearance of their names and titles in its bulletins or announcements.

There is no inherent difficulty in the plan of having two or three schools associated with the same hospital, interns from each working side by side, as they do at present in some of the larger hospitals, each intern under the supervision of some member of the staff who owes allegiance to the school from which the intern comes, and from which he is to receive his degree. Indeed, there are important advantages in having interns from two or more schools working side by side in the same hospital, with a common purpose, but stimulating and broadening each other's views and knowledge by the diversity of their previous education.

In these hospitals students in the earlier stages of the medical curriculum—that is, in the long vacations succeeding the sophomore and junior years—could, with advantage to the hospital, as well as to themselves, serve as externs, performing the simpler duties in the wards and laboratories under the supervision of the staff and the older interns. These long, four to six months' vacations, under the custom which has prevailed since the preceptor became obsolete, are a sad waste of time and inertia. Under the four-quarter system in Rush Medical College, the students may, if they choose, continue in residence about ten and one half months each year. In my observation of many students who have pursued this plan during the last twelve years, I have yet to learn of one who has been harmed physically, or otherwise, by continuous work during the four quarters of one or more years of his course of study.

The division of expense between the hospitals and any college with which it is affiliated should not be difficult of adjustment. The hospital, as a place for the care and cure of the sick, should bear the expense

of its maintenance for that purpose. The medical school, as an educational institution, must meet any additional expense entailed by the use of the patients for teaching or research, over and above that which would be required to give the best possible service to the patient in the effort to restore him to health. By no sort of logical reasoning can it be concluded that it is a just obligation of the college to pay for free beds because the patients occupying them are used for clinical demonstration. It is the function of a charitable hospital to maintain as many free beds—free wholly, or in part—as its income will permit. The hospital, as an institution, is entitled to credit for benevolence just in proportion to the amount which it expends on the hospital care of its patients over and above that which they pay for such service. Credit for free medical service rendered belongs to the medical staff of the hospital and to the college furnishing the staff—not to the hospital as such. The staff should utilize as clinical material any and every patient in the hospital, be he pauper or pay patient, who does not object to being so utilized. Of course the interests of the medical school and every affiliated hospital are mutual; both are engaged in rendering service to the sick, and each should assist the other in friendly cooperation to secure the necessary endowments to carry on their work.

I am not unmindful of the difficulties to be encountered in securing the effective cooperation of hospitals and medical schools, along the lines sugggested. Local jealousies among practitioners, keen rivalry between neighboring medical schools, parsimonious economy on the part of hospital boards, "ward politics" which dominate the control of many public hospitals, the lack of adequate endowment for both medical school and hospital—these and other hindrances to good work by both groups of institutions and, therefore, to effective cooperation, must be met and overcome.

It is because of the magnitude of these difficulties that great care and deliberation are necessary on the part of any medical school which proposes to make a fifth or intern year a compulsory addition to its curriculum. The diploma issued by any medical school should stand for thorough, careful education at every stage of the required course of study, and it should not be made to cover a fifth or intern year until the school can give to the student and to the world assurance of the same effective instruction, closely supervised under proper conditions, during this fifth year that is given during the preceding years of the curriculum.

MEDICINE AND SOCIOLOGY[1]

By C. R. Bardeen, M.D.,

Professor of Anatomy and Dean of the Medical School,
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It is a pleasure to have this opportunity to be with you at your commencement exercises. Rush has attracted many Wisconsin graduates medically inclined. Not only in the present graduating class but also among the members of your faculty I greet not a few Wisconsin men. Furthermore, the University of Chicago, with which Rush is officially affiliated, has a course in the premedical and medical sciences similar in ideals to the one we have at Wisconsin. In the premedical course at Chicago in addition to physics, chemistry, biology and a modern language some work is required in social science. Work of this kind is advised but not required at Wisconsin, but I am not sure but that it should be required there. There is ever greater need for sociology in medicine.

On the one hand, medical problems are at bottom social problems and are to be wisely solved only by those who have some knowledge of social science. On the other hand, the increasing complexity of the social organization brought about by the introduction of machinery and of rapid means of transportation of people, materials and news, the urbanization of the population and industrial concentration, have developed social problems which demand above all else the intelligence of men broadly trained in medicine. The triumphs of civilization are due to organization, to the subordination of individual whims to broad social aims. Its failings, on the other hand, are in large part due to the too constant appeal to selfish personal interests as an inducement to social effort. Much that is weak and inefficient in the treatment of disease by physicians is due to a too narrow preliminary training, to a too restricted attitude, to a selfish, competitive, unprogressive individualism, archaic and out of place in modern highly organized society. Many of the worst evils of our present-day civilization, dirt, ill health,

[1] Address delivered at the commencement exercises of Rush Medical College, June, 1911. Published in *Science*, October 20, 1911.

despondency, pauperism and crime, are in large part due to the failure on the part of the majority of those trained in medicine to act as leaders and public educators. Health of body and of mind should be recognized as of first importance to the community. "They have been so recognized, so far as they have been understood," says Havelock Ellis, "in every great period of civilization of which we have much knowledge, as Roman and Moorish ruins alone suffice to testify. That they are not so recognized to-day is the chief element of rottenness in our civilization. We postpone laying the foundations of our social structure in order to elaborate its pinnacles. We have not yet learned that a great civilization is ill built up on the bodies of men and women enfeebled and distorted by overwork, filth and disease."[2]

The marvelous advance in industrial productivity characteristic of the past century is due, on the one hand, to the ideal of learning all that is possible about nature by observation and experiment, in a word to scientific research, and, on the other hand, to the organized application of this knowledge to human needs. It seems not improbable that during the coming century an equally earnest effort will be made to learn the truth about mankind, by observation and experiment, in order that the application of knowledge to human needs may be made more efficient. Medicine as a science occupies a unique position in that, on the one hand, it is closely bound up with the physical sciences on which industrial productivity depends, with physics, chemistry and biology, while, on the other hand, it deals directly with people in their social relations and is therefore intimately related to sociology. This latter relation has not been sufficiently recognized hitherto by either medical men or sociologists. With the application of a scientific sociology to the needs of mankind the importance of medical science will come more and more to the fore.

About fifty years ago a witty Englishman said that the ancients had tried to make of medicine a science and had failed, the moderns had made of it a trade and had succeeded. There is truth in the statement. The medicine of the ancients was rather an art than a science. Empirical practise was ahead of the theories used to explain the nature of disease and its treatment. Medicine is still too frequently looked at from the standpoint of a trade, but since the Englishman gave his cynical opinion medicine has progressed as a science more than in all the centuries before.

[2] "The Naturalization of Health," 1892.

In the development of medicine four stages may be recognized, a demonic, a hygienic, a physiologic and an etiologic.

In demonic medicine disease is looked upon as an evil spirit which has taken possession of the body and which may be scared out by elaborate ceremonies usually accompanied by noise and supposedly fearful-looking objects. This type of medicine is found in practically all savage tribes and wide-spread even in semi-civilized countries like China and India and is not unknown in a less crude form in modern America.

In hygienic medicine disease is looked upon as an abnormal functioning of the body which can in large part be overcome by methods useful in keeping the body in healthful activity, by regulation of the diet, sleep, air, bathing, exercise and mental recreation. This type of medicine was brought to a high stage of development by the Greeks, among whom personal hygiene was practised to a degree of perfection which it has never elsewhere reached. To Hippocrates are ascribed the works in which the hygienic medicine of the Greeks is summarized. It has formed the basis of much of the best medical practise ever since. If, however, as some historians believe, the decline of Greece was due in large part to malaria, the Greeks in the end served to illustrate the inadequacy of merely hygienic medicine.

Physiologic medicine is based upon centuries of study of the structure and functions of the body in health and disease. It began among the Greeks soon after the time of Hippocrates and reached its highest development during the nineteenth century. It seeks to determine accurately just what structural or functional disturbances underlie the symptoms of a given disease, to what extent the disturbances are beneficial and to what extent detrimental, and what may be done to allay the detrimental and excite the beneficial disturbances. It has given rise to refined methods of diagnosis so that lesions of the heart, the lungs, the kidneys and other vital organs may be determined with considerable accuracy, and steps taken so far as possible to overcome these defects by use of drugs, operations or carefully regulated habits of living. It has shown that not all symptoms of disease are signs of an injured mechanism, but rather may frequently be signs of a vigorous healthy fight against invasion. Thus fevers are frequently, if not always, accompanied by the production of living cells or of chemical substances which attack invading disease germs. The fight may be lost and the mechanism may be permanently damaged, but on the other

hand the fight may be won. That a fight won against a mild invader may enable the body to resist a stronger one was shown in the latter part of the eighteenth century by Jenner, who discovered that inoculation with cowpox will protect against smallpox. This great discovery of vaccination soon proved a blessing to mankind, but nearly a century passed before scientific knowledge and methods became sufficiently developed to give us the Pasteur treatment for rabies, the Behring serum treatment for diphtheria, and the opsonic therapy of Wright, all based upon the idea either of stimulating the normal power of the body to resist disease or of stimulating an animal to resist disease and then utilizing its resistance products by injecting them into the human body. These biological methods of treating infectious or contagious diseases are to be contrasted with the merely chemical methods of which until recently but two were known to be specific: mercury in syphilis, derived from the Arabian use of the drug in cutaneous affections, and quinine in malaria, derived in the eighteenth century from the use by natives of Peru of Peruvian bark to cure fevers. Recently the genius of Ehrlich has enabled him to add at least one new specific drug, another cure for syphilis, and to open a new field for work.

In another direction physiological research has shown that when an organ whose secretions are needed for normal activities is deficient its place may sometimes be taken by extracts from organs of the lower mammals. The use of thyroid extract in cretinism and myxœdema is one of the greatest gifts of physiology to medicine. Nothing is more astonishing than the development of a cretin, otherwise destined to a dwarfish, toad-like existence, into a nearly or quite normal individual when fed on the extract of thyroid glands of the sheep.

Modern surgery is an outgrowth of physiological medicine, although many of its triumphs are due to asepsis, and this in turn is a product of the stage of medicine next to be considered, the etiologic.

Etiologic medicine seeks to determine the causes of disease and to deal directly with these. It is a direct outgrowth of physiologic medicine and has really been the aim of the foremost students of the physiology of disease. While the causes of some diseases have been fairly well understood for many years, etiologic medicine was first really placed on a firm basis by the genius of Pasteur and Koch about fifty years ago. In infectious and contagious diseases the specific organisms and their mode of transmission have been discovered in a large number

of cases, and in others much has been learned even where the specific organism has not yet been discovered. Thus one species of mosquito is known to transmit malaria, another to transmit yellow fever. The malarial organism is known, that of yellow fever is not. Malaria can be fairly successfully treated with quinine. There is no specific for yellow fever. Both diseases can be abolished by getting rid of the mosquito. Typhoid fever, for which there is no specific, can be gotten rid of by guarding water and food supplies and for a time, at least, guarding the public against typhoid carriers, people who harbor the germs without themselves being sick. Such carriers, however, would probably not exist where the water and food supplies have been kept pure for years, except, of course, as they might come in from outside. Tuberculosis is a more difficult problem, but by guarding the air and food supply and by teaching consumptives how to keep themselves from infecting others great advances can be made toward getting rid of this disease.

Tuberculosis offers perhaps the best example of advance from the physiologic to the etiologic attitude toward disease. The history of recent advance in the study and treatment of tuberculosis has been well summarized by R. W. Phillip.[8]

The remarkable advance in the medical sciences during the last half century has been due chiefly to the development of research laboratories in universities, in special research institutions and in the government service. In spite of relatively meager funds these institutions have provided instruments and inspiration for search for the truth; the work has been led by men of genius, and has been organized so as to promote cooperation without destroying initiative. For the most part these research laboratories have been connected with laboratories of medical schools, although in this country such connection has been unfortunately too rare. Where such a connection exists, as at Chicago and Rush, the investigator is stimulated by the youth about him while the younger men are inspired with ambition for that real power which comes from scientific knowledge.

In the application of medical science to human needs America has been much more backward than in the advance of medical science. This is due probably chiefly to the fact that a very few men can advance

[8] "Progressive Medicine and the Outlook on Tuberculosis," *British Medical Journal*, 1909.

medical science enormously if they be of the caliber to discover essential truths and have the right environment. One or two research institutions or a government inclined to give even meager support to medical investigation makes possible the work of a Walter Reed, who is primarily responsible for the proof of the conveyance of yellow fever by mosquitoes, or of a Ricketts, whose work on spotted fever and on typhus fever will, in spite of his untimely death, cause his name to be lastingly remembered. On the other hand, in order to have an effective application of medical science to human needs there must be a sufficient number of men well versed in the science to make it possible to educate the whole people to an understanding of its practical value. This, owing partly to the backwardness of so many of our medical schools, we have not had. In the Wisconsin legislature, a "progressive" legislature at that, bills relating to instruction in hygiene and to medical inspection in the public schools have failed to pass because a handful of christian scientists exerted more influence than a medical profession of three thousand. On the other hand, this same legislature has been quite liberal in providing for state and county institutions for the care of tuberculous patients, but here there has been public education largely led by laymen.

Demonic medicine to a large extent still holds sway. Among the christian scientists the evil spirit is known as "error," among the chiropractics and similar cults as "dislocated vertebræ," among the people at large as something vaguely formulated but none the less something to be driven out by various kinds of patent medicines for which each year many millions of dollars are spent. The cures which these various forms of demonic medicine sometimes effect are ascribed by the scientific to the action of the stimulated imagination on the body. This has given rise to a new "psychotherapy" in which the effect of mind on body can be utilized scientifically. Psychotherapy, however, is to be looked upon as a branch of physiologic medicine. Demonic medicine has no longer a place in a truly civilized community.

Hygienic medicine, on the other hand, is a lasting gift from the Greeks to civilized mankind. Its basis is personal hygiene, the right use of exercise and rest of mind and body, diet, bathing, fresh air, sunshine, proper clothing and the like. It is primarily the medicine for the home and must depend largely on the intelligence and education of home-making women. In its more specialized aspects for the

cure rather than the prevention of disease it is highly developed in our better sanitariums where regulated exercise, selected diet, hydrotherapy, electrotherapy and the like are carefully designed to restore a weakened individual to healthful strength of body, and in hospitals for the insane where the aim is to restore the mind. During the past fifty years in the hands of trained nurses it has transformed general hospitals throughout the world from places of excessive mortality into the safest places in the world in which to be sick. For years to come it appears that trained nurses are likely to be able best to carry its lessons into the schoolroom and the home as they already have into our hospitals, thanks largely to the genius of Florence Nightingale. Modern surgery owes its triumphs fully as much to the trained nurses in our hospitals as it does to anesthetics or asepsis. School nurses to look after the health of school children under the supervision of medical inspectors, and district nurses to carry the lessons of hygienic medicine into the homes where at present babies are so badly cared for that a fifth of them die in the first year and a third die before the age of five, are essential for the advance of health under the guidance of medical science. To the physician engaged in private practise the nurse trained in hygienic medicine is indispensable.

The practitioner, although he must be able to apply or to direct others to apply appropriate hygienic measures, is himself primarily responsible for physiologic medicine, for the accurate diagnosis of disease and the medical and surgical treatment of the sick individual. He must be able to determine accurately the condition of the more important internal organs and be able to apply drugs or other treatment with due regard for these conditions. While many rough-and-ready methods of diagnosis may be used in the home or at the office, many of the more refined methods are here excluded by lack of time or equipment. Thus only too frequently a serious condition is overlooked at its inception and when discovered is so far advanced as to make a cure difficult or impossible. A large percentage of cases of tuberculosis are not recognized until well advanced, in spite of the recent agitation about the disease. This neglect to recognize tuberculosis early will be a standing disgrace to the profession so long as it exists.

Under present conditions of private practise crude, rough-and-ready methods of diagnosis are in many cases the best that can be utilized. A refined method poorly executed is worth far less than a rough

method carefully and intelligently used by an experienced, keen-sighted, thoughtful man. But the public has a right to demand the more refined methods. Within a generation we have seen most of major surgery transformed from the home to the hospital. There the surgeons can depend not only on the nursing staff to provide better hygienic treatment than is possible in the home, but he can also in a well-manned hospital depend on the internes to utilize many of the more refined and time-consuming methods of diagnosis. To these factors surgery owes no small part of its success.

In internal medicine the hospital is likewise becoming more and more utilized. Sanitariums with highly developed means for applying hygienic treatment have long been popular in the treatment of chronic troubles. Hospitals have not been sufficiently used for the diagnosis and treatment of disease in its inception and less severe aspects, but everything points to a rapid development in this direction. What is needed is more cooperation and less competition among the physicians in any given community. With better cooperation hospitals fitted for diagnosis and treatment could readily be established in sufficient numbers to give every physician a real hospital connection, except possibly in some very small towns. Each hospital should have a laboratory managed by one or more men skilled in the laboratory diagnosis of disease. There would then be no longer an excuse for mere rough-and-ready methods of diagnosis. Nor would it be necessary for the more scientifically inclined physician to maintain at great personal expense a private laboratory of his own. A greater amount of specialization on the part of the various physicians in a community would likewise greatly add to their efficiency, provided the specialization came on top of, not at the expense of, a broad medical training.

In sanitariums it is customary to make a general charge for room and treatment, special fees being made merely for surgical operations. The physician at the sanitarium, if not the owner thereof, is usually on a salary. At general hospitals the charge is usually for room and nursing, and other hospital care, the patient, if able to pay, paying the physician or surgeon caring for him directly for his treatment. The medical staff of the hospital seldom is on a salary, although a small sum, in addition to room and board, may be paid the interne. At the Johns Hopkins Hospital, where some of the members of the staff have always had some salary as compensation for their care of the indigent,

it has recently been proposed to put all of the members of the regular staff on a salary basis, on the understanding that they are not to engage in private practise. The private patients at the hospital would pay the hospital directly, and not the attending physician or surgeon, for their medical care. How wide-spread such a movement will become can not at present be predicted. In all probability, however, for many years to come the majority of physicians will depend for their support upon fees from patients rather than upon a salary from a hospital or other organization. The freer use of hospitals by no means precludes this.

On the other hand, it is quite apparent that the custom of the employment of physicians on a salary to give medical attendance to groups of people is growing throughout the civilized world. In public institutions for the care of the criminal, the insane and the defective, as well as in the army and navy, this custom has long prevailed and in this country has received the general sanction of the medical profession. The employment of physicians by corporations to look after men in remote districts has also received general sanction. But the profession has not looked favorably on the employment by corporations of physicians to look after employees and their families in settled communities where there is an abundance of private practitioners. Nor has the profession looked with favor on the employment at a salary by lodges and other social organizations of physicians to look after members and their families. "Contract practise," as these forms of practise are called, has a bad name, in large part deserved, because too often a physician will contract to treat for a sum too small to make good service possible. When a fair salary is paid for first-class work no legitimate criticism can be made. Certainly there is nothing sacred about the prevalent system of small fees for visits, fees which resemble in some respects tips to a servant for personal service, except that the physician's fee is less often paid in cash. On the other hand, there is nothing especially to be commended in the custom of the specialist, Robin-Hood-like, to hold up the rich sick to pay for the sick poor. The public at large should pay for its necessary charity.

A physician should be paid for his time and his skill and be paid enough to make it possible for him to give good service and improve himself in his profession. But whether he is paid a salary or a fair amount for a definite service makes little difference. The evil to the medical profession of the medical insurance laws of Germany comes

not from the fact that the state hires physicians to treat the insured, but from the fact that the state pays far too little for this service.

Much complaint is made of the large numbers who seek free treatment at dispensaries and hospitals in our larger cities, frequently a quarter or more of the population. It is doubtful if so large a part of the population are either paupers or dead beats. Many can not afford fancy fees and know of no way of getting the best treatment except to go to a dispensary or hospital where treatment is organized. Make it possible for the average man to get the benefits of organized treatment at a moderate charge and a large part of the so-called dispensary and hospital abuse will disappear.

There will doubtless always be some necessity for charity work. The community should pay the hospital and the physician for such as is really necessary. To what extent, beyond mere charity work, the public should pay for treatment of disease by physicians there is room for an honest difference of opinion. Some would have all medical treatment furnished free by the state, others would have none. Most of the profession, as pointed out above, approve of the state employing physicians in the army, the navy and in charitable and penal institutions. In public educational institutions the state is under special obligations to safeguard the health because of the compulsory features of our educational laws. While much can be done along the lines of sanitation and preventive medicine in the schools, much treatment must be given individual pupils if this work is to be effective. Where the law provides for medical supervision of the schools it usually provides that the family of the child shall be notified of the need of treatment and shall be expected to employ a physician for this purpose, except in charity cases where special provision is made. At present this is probably the most practical system, although only from twenty to eighty per cent. of children needing treatment actually get it. It is most efficient where there are school nurses to follow the children to their homes and explain matters to the parents.

The need of proper medical treatment during school life is illustrated by the son of a well-known physician. The boy was slow in the grades, and took five years to get through college. In some doubt the father allowed him to begin a course in medicine. Soon after he entered the medical school some one suggested he needed eye-glasses, although he never had supposed he needed them. When these were

obtained a new world was opened, continued study became possible and marked professional success followed. A pair of glasses in the primary school might have saved the boy some years in school and much chagrin.

In normal schools, colleges and universities an increasing amount of attention is being given to caring for the health of the students. This care takes several forms. Instruction in personal and public hygiene is now quite general and is required in a majority of colleges. Departments of physical training designed to promote physical health are also quite general. Committees to look after the sanitation of the grounds and buildings are common, but have not in most cases been given sufficient authority to do really efficient work. Class-room ventilation, for instance, is in general wretched. In several of the universities infirmaries are provided to take care of sick students and in others medical advisers or school physicians are engaged to advise or treat those who are ill. Sometimes a special fee is charged each student to provide funds to cover the cost of this medical service, at other times it is paid for out of general university funds and in some instances treatment is free for poor students while the well-to-do are supposed to pay for services received.

At Wisconsin we have a medical adviser with a staff of three assistant physicians, two nurses, a trained laboratory assistant and an office attendant. Careful medical examinations are made of all freshmen and of such upper classmen as require it. Regular daily office hours are held for consultation with students, office treatment is given and some visiting is done at rooming houses of students confined there by illness, although in severe or prolonged illness the student is expected to get his own physician when he can afford to pay. More treatment is given than was originally contemplated, but our experience in Madison has demonstrated that mere advice counts for little unless it comes from one whose ability to do commands respect. The hygienic talks given to individual students by the medical adviser and his assistants are far more effective than any public lectures on hygiene could be, because the staff commands the respect of the students by its ability to diagnose and treat disease. This, I believe, will be found generally to be the case in all institutional medicine.

In the diagnosis and treatment of disease etiology plays an important part, but the great triumph of etiologic medicine lies in the possibilities for preventive and social medicine which it has opened up. In

preventive medicine the state through education, legislation, inspection and regulation plays an essential part. Preventive medicine can only be made effective where the state employs highly trained men to look after sanitation and hygiene. Nearly all diseases at bottom are social and can be properly repressed only by social cooperation.

Indeed even the most individualistic diseases, congenital defects of various sorts, may be frequently traced either to bad or vicious surroundings of the parents or to a bad ancestral line on one or both sides. Eugenics, the new science which seeks to determine the laws necessary for propagation of an improving species, will have to be studied both by the family physician who is to be a wise councilor and by public health officers who aim to be good teachers and guides. Sociological medicine begins not only before birth, but even before conception. The life of young women must be made healthful, young men must be made to understand the lasting effects to the third and fourth generation of drink and the social vices.

At birth again sociologic medicine has its important part to play. When the clean hospital with its specialists comes to be substituted for the dirty midwife and the so frequently bungling general practitioner years of ill health and suffering will be saved the larger share of our married women and our blind asylums will become one fourth too large. Havelock Ellis estimates that in England in 1891 midwives were responsible for the deaths of three thousand women. They were doubtless responsible for the lifelong suffering of many more. It is estimated that about a fourth of the blindness in our blind asylums is due to lack of proper care of eyes at birth.

During infancy the death-rate is frightful. While doubtless the fittest survive, they do not survive in the fittest way. An abundance of well-trained district nurses under careful medical supervision could do untold good in this field of sociologic medicine.

A fifth of the population are in the public schools. Here sociologic medicine has already made a good start. In most of the large cities moderately efficient medical supervision has already been established and in the smaller towns it is beginning. Massachusetts has a state law making it compulsory in the public schools to provide a medical adviser and several states have permissive laws. It is the duty of the medical inspector to see that children suffering from contagious diseases are excluded from the school during the infectious period, to examine

for defects in the eyes, ears, nose, teeth and throat, to advise treatment when necessary, and in general to look after school hygiene and sanitation. As already twice pointed out, the school medical inspector has his efficiency greatly increased when school nurses are attached to his staff. It has been suggested, quite wisely, I think, that there be an abundance of school nurses who can not only follow the children to their homes and see that they are cared for, but also act as district nurses to give advice concerning care of infants and general hygienic conditions. The greatest drawback to medical inspection has been lack of sufficient funds to employ enough specially trained men and women at full time to do the work thoroughly. Open-air schools for weak children and special schools for defectives are a natural outgrowth of medical supervision of school children. Chicago is to be congratulated on the splendid start she has made along these lines.

While we can depend on proper medical inspection in the schools and school and district nursing for a great improvement in personal hygiene and in the popular intelligence concerning medicine and hygiene, the care of the public health will depend in no small degree on efficient officers of public health. At the present time these are rare in the United States.

A vast amount of preventable disease exists for which there is no intelligent excuse. There should be practically no typhoid fever, but thousands die from it yearly. Smallpox should be rare, but in the middle west it is quite common. Most of the contagious diseases could be greatly reduced by more efficient boards of health. The milk supply, in most cities, especially those of moderate size, is far too little intelligently supervised. Fortunately, conditions are changing and within the present generation there should be such a demand for well-trained officers of public health that it will be difficult to keep up the supply. Our medical schools will recognize that the training of public health officers is a duty equally important with that of training practitioners of medicine. At Wisconsin, next year, we are to begin a course in public health and we hope within a short time to find a real demand for such a course. The splendid public health work done by our government in Cuba, the Canal Zone and Manila shows what Americans should soon be doing at home. We need a national health bureau and we need in each state and in each district and municipality in each state thoroughly competent health officers. You young men about to graduate must do your best to promote this movement.

Efficient sanitation depends above all else on public education. In tuberculosis splendid progress has already been made along these lines, but much more remains to be done in the general field. The medical profession should do far more than it has done to educate the public. Sanitary laws will be efficient in a democracy just in proportion to the general intelligence about hygienic matters, and no more.

Medical advance depends, on the one hand, on scientific research, on the other on public education along hygienic lines. Every citizen should be inspired with love of personal and public hygiene as were the Greeks. Every physician should be deeply grounded in physiologic medicine and provided with proper facilities for using it practically. Every officer of public health should know thoroughly the contributions of etiologic medicine. All efforts should be made to promote these most fundamental needs of society. While most of you who are graduating to-day will become private practitioners, most of you will be in a position directly or indirectly to promote scientific medicine, public education and public sanitation. You have had as students at Chicago University and at Rush splendid examples before you in your faculty. With such examples none of you can fail to play well your part in helping in the organization of society along more hygienic lines and in the reorganization of medical practise to better fit the needs of modern society.

THE RELATION OF RESEARCH TO TEACHING IN MEDICAL SCHOOLS[1]

By W. Ophüls, M.D.,

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Much of the future development of medical education will depend on a proper solution of the problem of the relation of research to teaching. In the course of the last decade our medical schools have made great strides in advance. In many of our best institutions the teaching of the fundamental, more theoretical branches is as good as, if not in some respects better than, in the old centers of medical culture in Europe, and we are just about to apply to our clinics what we have learned in our laboratories. It is at this point that we should pause for a moment and consider seriously in which way our desire to place the teaching in the clinics on the same level with that in the laboratories can best be accomplished.

There are certain points about which there should be general agreement; first of all that nobody can be a good teacher of medicine, surgery or its various branches, any more than of any other branch of the biologic sciences, who is not an investigator and endowed with that natural power of observation and that inborn curiosity in regard to the phenomena which he does observe which necessarily leads to research. This does not, of course, mean inversely that every good investigator is a good teacher. To some extent, at least, the true investigator is born and he can not be entirely the result of training even from the most ambitious material.

It is only through research that the atmosphere of scientific enthusiasm can be created in which the work of the student prospers. It is also through research only that the necessary bridle is placed on an exuberant scientific imagination, and the great temptation to too rapid logical generalization is happily avoided. Through it one is led to the proper degree of conservatism in judging results, and as a consequence

[1] Published in the *Journal of the American Medical Association*, February 24, 1912.

of it one develops that state of simple-mindedness and true humility which we admire so much in all our truly great men.

It also goes without saying that no man, however great, can attempt to do research by proxy, which, however, seems to be a common delusion. The most important part of the work must be done personally, which means that the teacher in medicine and surgery must devote much time to his academic duties; how much exactly, is, to my mind, a matter of less importance. Time and experience only can tell whether it is wise to shut off such men entirely from active practise on the outside; but that they must devote the larger part of their time to teaching and research, if they wish to be effective, nobody will deny.

The question then resolves itself into this: How can we attract the men who have the necessary qualifications to take teaching positions in medicine and surgery in our medical schools?

There is one answer which we can dispose of fairly summarily, and this is to better present conditions by offering high salaries to the clinical teachers. The argument has been made that, because a physician or surgeon may earn much money in private practise, therefore the chairs of medicine and surgery must be very highly endowed to attract the best men. The fallacy of this argument is at once apparent, if we look at similar cases which have long been settled. Is not what has been said of medicine and surgery equally true of chemistry and engineering? Industrial chemists and practising engineers may make, and often do make, vast fortunes, larger by far than even the best practitioners could hope to accumulate, still there is no dearth of professors of chemistry or of engineering. The right man will never be prevented from choosing an academic career by such considerations. He must be paid a good living salary according to his surroundings, but nothing more or less. The salaries paid for professorial positions in general are inadequate, especially in the larger cities, but from $8,000 to $10,000 a year would certainly be ample at the present time.

What the clinical teacher, however, can require and what he must require are facilities for work. He must have the necessary material to work with, the necessary laboratories to work in and the necessary assistance to make his own work effective. If money is to be spent, it is best invested in this direction and it will take much money to provide the professor in the clinical branches with the necessary beds under his absolute control, with the necessary laboratories and their expenses for

equipment and supplies and with the necessary assistants. On this account the provision of these necessities is the one object on which those who are in control of our medical institutions should concentrate their efforts. On account of the strong appeal which the development of such clinics would make not only to those who are primarily interested in education or in the development of medical science, but even more to all who are interested in charity, since a proper medical treatment of the poor is perhaps the one form of charity which is free from all objections, the necessary funds should be obtained with comparative ease, if only the crying need for such institutions was well understood by the laity.

On account of the large means, however, which are necessary and on account of the urgent, one may say even vital, need of our medical educational institutions for such well-equipped and properly run clinical services, one is justified in watching with some apprehension certain recent developments which may seriously interfere with this object and withal with the healthy growth of medical thought and knowledge in the United States. I mean the overhasty establishment of special institutes for medical research and of special professorships of research medicine.

One may be surprised at the thought that special institutes for medical research may carry with them a danger to general medical education. What I wish to say does not apply so much to those larger institutes which are independent and endowed liberally, like the Rockefeller Institute in this country, the Pasteur and Jenner institutes in Europe. The dangers there are more evidently dangers to the men within the institute than to those outside. It is true that the men connected with them are relieved of the drudgery of teaching and examinations; they are not interfered with in any way with their scientific aims and aspirations, but they must miss the vitalizing influence of youth, of the constant stream through the laboratories of classes of students with their still undeveloped, potential energies, of students from whom, after all, the future investigators recruit themselves. It is true that the younger assistants replace them to a certain extent, but only very imperfectly. These men must lose in course of time somewhat the sense of relation between their own work and the rest of medical knowledge. They must lose in breadth by not being compelled to pay some attention to any part of the field except the part in which they happen

to be interested. Marvelous results may follow such intensive cultivation, but there also is, at least, the danger which is common to all types of forced cultivation.

There is no doubt that under certain circumstances and for certain men such institutes are a necessity; the Pasteur, the Jenner, the Rockefeller institutes and others have justified their existence over and over again, but, to my mind, it is the exceptional work which demands them and it is the exceptional character who thrives in such surroundings. At any rate, they should not be multiplied unnecessarily at the expense of funds which might be available for more general purposes.

Such institutes constitute a real menace when they are coupled up with an educational institution, unless they assume an educational function and do their share of teaching as well as research. As a general principle, the research institute has as much the duty to teach as the true teacher has the duty to keep his information alive by research. The separation of research from teaching in an educational institution is fraught with real danger because it takes away from the teacher that which is his just due. How does one imagine that it will be possible to fill the teaching position with the very best man if there is side by side with him another for the express purpose of doing that part of the work which should be nearest his own heart? It is true that experience shows that even under these adverse conditions the "teacher" often does as well as if not better than his research fellow, but I am sure the average board of trustees will hardly understand why, after having so splendidly equipped the research department or after having it equipped for them by an endowment, they should do much more for the teacher than to give just what is absolutely necessary for teaching purposes. If the best man must choose under such circumstances he is sure to select the research work, and so the student, who should certainly be entitled to instruction by the best man available, loses.

The trouble, of course, in some cases, is that research in the abstract appeals more strongly to those who are willing to give the means for such purposes; still I believe that with proper information such individuals would be perfectly willing to give the money in such a way that it could be used for research without crippling teaching.

If we apply this to the conditions in medicine and surgery it is evident that, far from putting such a discouragement in the way of our future professors of medicine and surgery, we should carefully see to it

that whatever means are available for research are at their direct disposal. It is possible by good assistance to relieve a man in many ways from unnecessary drudgery and in this way give him ample time for that most important part in the pursuit of new knowledge in his department, which he must do himself. In fact, when we look at the life-history of our great men, we find that they have found time for such work in spite of almost insurmountable difficulties, in the way of time and equipment, and who will say that the tremendous struggle was not part of their success? Still I firmly believe that unnecessary friction should be avoided, all clerical and administrative work, if necessary, examinations, etc., got out of the road; then it will become apparent that it is not so much teaching as a mass of other much less important detail which has clogged the machinery.

In other words, for our teaching positions in medicine and surgery we must get the best men available, and in order to get them we must carefully guard the positions which are to be filled by them, and see to it that they really become attractive to the best talent.

From this point of view the establishment of chairs of research medicine is an even more serious mistake. Research medicine is no special branch of medical knowledge that is worthy of a representation in a medical faculty. The mere existence of such a chair in a way reflects on the work of the rest of the members of the faculty. But one may say: Your objections are directed against words rather than against facts. The title is merely a misnomer and experimental pathology or pathological physiology is really what is meant. Even then the experiment remains objectionable because it places something between pathology and medicine which should not be there. There is no doubt that our medical schools will prosper just so much as they will do work in "research medicine," but that this type of work should be intimately connected with the clinics no one will doubt. Investigations of this character are the one thing necessary to rejuvenate our teaching in medicine and surgery. Why increase the existing evils by giving the men in the so-called practical chairs an excuse for not doing what it is plainly their duty to undertake? The only reasonable step to take is to force our laboratories into our old musty clinics. We must get fresh air, a different atmosphere and a truly scientific spirit into them, and the only way to do this is by making residence in them congenial to the true investigator.

I do not wish to be understood as saying that the only qualification which the clinical professor of the future needs is proficiency in laboratory work; far from it. There are only few laboratory workers who possess that additional experience and those additional gifts of talent and character which can rightly be demanded of a leading clinician, but that he should have a fundamental training in the methods of investigation in physiology and pathology seems self-evident. The life-history of all our great clinicians is sufficient warrant for this assertion; and I also believe that another assertion can not be easily challenged, namely, that the experimental investigation of those physiologic problems which are intimately connected with the manifestations of disease can be best done in laboratories directly connected with the clinics and not on the outside in separate institutions.

I present these views for the consideration of the members of the medical profession at large with the hope that they will take a real interest in the matter, first, because in the long run we shall get those conditions in our medical schools which the consensus of the great body of well-trained physicians demands; and second, because the endowments which are to realize our ideals must come largely through the personal influence of those who in active practise come in contact with wealthy individuals who are anxious to use what they possess for the immediate benefit of their fellow men and for the common welfare of humanity.

THE SCIENCE OF CLINICAL MEDICINE: WHAT IT OUGHT TO BE AND THE MEN TO UPHOLD IT[1]

By S. J. Meltzer, M.D., LL.D.,
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The honor of the presidency of a society goes with the privilege of discussing some of the aims of that society. Such a privilege becomes a duty on the occasion of its first birthday. We have to show the specificity of our objects to justify the addition of a new medical society to the many already in existence. As your first president and as one of the instigators of the movement which led to the formation of this association permit me to discuss some of the problems to the solution of which this association wishes and hopes to contribute.

Clinical Medicine as a Science

In the first place, I wish to discuss the problem of clinical medicine as a science. In years gone by, medicine was a unit and its leaders tried to master all its aspects. With the development of scientific methods and the growth of knowledge a process of differentiation took place. Heavy branches grew out of the stem of medicine, broke off and obtained an independent existence. Anatomy with all its dependencies broke away early, then followed physiology, pathologic anatomy, pharmacology and physiologic chemistry. Bacteriology tore off the branches of etiology and established itself as an independent growth. All these offsprings of medicine are now well established as pure sciences; they still closely affiliate with the mother-stem and are often designated as the sciences of medicine. That what is left of the old stem is clinical medicine. What is the character of this residuum? It is generally designated as the practice of medicine. I am not aware that any one has had the courage to call it a pure science. Those who do not like to call it an art say that it is an applied science. According to this view, the relation of clinical medicine to the sciences of

[1] Presidential address at the first meeting of the Association for the Advancement of Clinical Research, May 10, 1909, Washington, D. C. Published in *The Journal of the American Medical Association*, August 14, 1909.

medicine is that of technology to science in general. I am afraid that this conception of clinical medicine is wide-spread among those who are in the practise as well as among those who are in the sciences of medicine.

However this may be, I feel sure that such a view is logically erroneous and practically harmful. I wish to plead for an extension of the process of differentiation also to clinical medicine. I am of the opinion that clinical medicine as it exists now is made up of two constituents: one part has all the elements of a pure science and ought to be coordinate to the other pure sciences of medicine, and the other part is the real practise of medicine, an applied science which has many elements of an art. At present both parts are so closely interwoven that they present the appearance of a natural unit the splitting of which into two parts might appear to some as an impossible and undesirable process. I shall call to mind, however, that medicine made the same impression of an indivisible unit in the days when pathologic anatomy, physiology, etc., were inseparable constituents. To-day nobody doubts the necessity of an independent existence for the last-named constituents of former medicine. A considerable degree of separation of the science of clinical medicine from its practice is more desirable than even the separation of the coordinate sciences, because the requirements of sciences and practice are in a certain sense mutually antagonistic to one another and the simultaneous cultivation of both branches with equal attention is detrimental to the progress of either of them.

There is a fundamental difference between science and its correlated practise in any sphere of human activity. Science wishes to attain truthful knowledge of the subject it investigates. It attains this end in the safest way when it is least side-tracked by any extraneous motives. The motive of utility obscures its vision, and haste retards its progress. Practise, on the other hand, avails itself of acquired knowledge for the purpose of attaining a certain useful end. The more reliable that knowledge is which it has to employ, the more safely will it attain that end. But the use of any part of that knowledge which is indifferent to the attainment of the useful end hampers the practical progress. In other words, practise gains its ends best the purer the quality and the smaller the quantity of the science which it has to use. Permit me to say that my advocacy of the separation of a clinical science from its practise is not actuated by any disregard for the practise of medicine.

On the contrary, I entertain now and have always entertained a strong conviction that the efficiency of practise should be the supreme object in medicine. At the same time I feel sure that the efficiency of that practise will be best attained when the search for the knowledge which the practise has to use should be carried on in the same manner and by the same methods as are employed in the search for knowledge in other branches of intellectual activity. In other words, clinical research should be raised to a department of a clinical science and be theoretically and practically separated to a considerable degree from the mere practical interests, that is, separated so far as the various and variable conditions permit. It will be the practise not less than the science of medicine which will benefit by such a separation.

Now let us see what the domain of clinical medicine is and whether it contains problems which can be treated by the methods employed in pure science. The sciences of normal anatomy and physiology teach us the structures and functions of the normal body; pathologic anatomy tells us of the anatomic changes found in a body dead from one disease or another. To clinical medicine is left the study of the phenomena and their sequence as they occur in a living body during the entire course of a disease. It has to interpret these phenomena by known physiologic laws, to identify them with similar phenomena experimentally produced in animals and it has to correlate the phenomena observed in the course of a certain disease during life with the anatomic changes found at the post-mortem examinations in case the disease has a fatal termination. It is also one of the tasks of clinical medicine to study the influence on the onset and course of phenomena of diseases which certain means and remedies may exert whose physiologic actions are well established. In other words, the domain of clinical research comprises the study of the natural history of diseases, their physiology and their pharmacology. Can there be any doubt that these studies constitute legitimate objects of a pure science? Objections may be raised, and will be raised in certain quarters, against the admission of the clinical science to the sacred inner circle of pure sciences on account of the impossibility in clinical medicine to verify the conclusions by the experimental methods. Assuming that this is an unassailable fact, what of it? Are the problems of biology, a science which enjoys an unassailable position in the councils of pure sciences, all or many of them provable by experiment? Or are the sciences of paleontology or geology amenable to an experi-

mental proof? Yet nobody questions the scientific right of these branches of human knowledge. Furthermore, admitting that clinical research must necessarily remain less precise and its results less convincing than that, for instance, of physiology. But, then, physiology itself is again a great deal less precise than physics and chemistry and is certainly less irrefutable than anatomy. Does this throw a doubt on the claim of physiology to be a pure science?

As to the impossibility of verifying certain conclusions regarding human diseases by human experimentation, there is still this much to say. Each disease is an experiment which Nature makes on the organism. The very large number and the great variations of these experiments of Nature offer favorable opportunities for testing the theories made regarding the nature of these spontaneous experiments. Furthermore, clinical research should, indeed, be coupled with animal experimentation; any new point of view gained by observation in clinical medicine which can not be verified on human beings should be tested by experiments on animals. By such a procedure not only clinical medicine, but also physiology, may learn a good deal, for which the following facts from the recent history of medicine are classical illustrations. The recognition of myxedema as a special type of disease led to the understanding of the function of the thyroid glands, and the observation of the coincidence of pathologic processes of the pancreas with diabetes led to the discovery by clinical investigators of the glycolytic function of the pancreas. Finally, it should be borne in mind that there are lines of experimentation which may be carried out even on the sick human being without any detriment to him and which can be conducted with profit only by trained scientific observers; for instance, some studies in pharmacology or in metabolism. Among the tasks of clinical medicine there is one which is on the borderland between the science and practise of medicine, being perhaps of greater importance to the latter than to the former. It is the search for simple or complicated means by which established units of diseases may be recognized safely and perhaps also easily. In one word, it is diagnosis. Since this activity is not carried on with a purpose of adding knowledge, it would appear that it belongs rather to the department of the practise of medicine. Such facts can be established only by means of careful critical observations and it will be more to the purpose when at least the development of the principles of diagnosis should remain in the hands trained in careful methods of research.

After showing that there is a definite field for a science of clinical medicine, the next question is who should be the men to carry on the research in this field, what should be their qualifications? In the first place, they must have a training fitting them to carry out investigations in conformity with the requirements existing in all pure sciences. They must not only be informed and trained in the other sciences of medicine, but must have carried on various investigations in one or more of these pure sciences, so as to become familiar with careful scientific methods and imbued with a scientific spirit. They will thus learn best how to shape a problem so as to make it amenable to a solution; how to marshall the consecutive steps of an investigation so as to bring out the reply to the question in hand. They will learn to avoid bias in the search, to apply criticism to the findings; they will learn not to trust only few facts, not to rejoice prematurely over findings and not to be disheartened by failures. They will thus acquire the habits and the tastes of the investigator, the scientist, which may then stick to them for life.

However, after all these preparations they must select clinical research as the main field of their scientific activity. Clinical science will not thrive through chance investigations by friendly neighbors from the adjoining practical and scientific domains. Such volunteer service which for the present is keeping up the cultivation of the unacclaimed region is most certainly very welcome. But the acclamation, cultivation and maintenance of a field of pure science of clinical medicine can not be accomplished by chance services from volunteers; for such a purpose we need the service of a standing army of regulars. The investigator in clinical science must devote the best part of his time and intellectual energies to the cultivation and elevation of this field just as the physiologist does in his domain—or at least as he ought to do. For the sake of elucidation let us compare the relations of a science of clinical medicine to its practise with the relations of science to technology in any part of physics or chemistry. Let us take electricity as an instance. In the electrical industry there is a large corps of electrical engineers who are bright, inventive and on the alert to make practical use of any newly discovered principle in general. Some practical engineers manage to make valuable contributions to the theoretical knowledge of their branch. Nevertheless the science of electricity is in the hands of pure scientists who are setting the pace of progress in the

correlated practical branch. It is the discovery in pure science which makes great inventions possible. It was, for instance, the purely scientific demonstration by Hertz of the existence of electric waves that gave the impetus to and made the invention of wireless telegraphy possible. The following is a quotation from the presidential address of Professor Nichols before the Association for Advancement of Science:[2]

Communities having the most thorough fundamental knowledge of pure science will show the greatest output of really practical inventions.

This is surely true also for medicine. And let me say to you that the Hertzes, the Roentgens, the Bunsens, the Emil Fischers and a host of others, who are the real creators of knowledge and invention, are satisfied to live on comparatively small salaries, while it is within their easy reach to make twenty times the amount of their salaries as consultants, if they would be willing to give up a part of their time which they devote to investigations in pure science. Now, the leaders in practical engineering in electricity surely compare favorably with the leaders in the practise of medicine with regard to the completeness of their knowledge in the respective spheres. While thus the search for knowledge in electricity is carried on by men devoting themselves to pure science, the search for knowledge in clinical medicine is left in the hands of men who devote most of their time and energies to their practise and to the golden fruit it bears. Under such circumstances, how shall we expect to find the progress in science and practise of medicine keeping abreast with the striking progress to be met with in other branches of science and practise?

A few years ago I tried to fix the responsibility for the shortcoming of internal medicine to physiology, because this science is keeping aloof from medicine and its problems.[3] Anatomy, which gave its undivided attention to the human structures, prepared an excellent basis for a successful surgery, the problems of which are essentially mechanical in character. The problems of clinical medicine are essentially of a functional character, and the enlightenment which it requires must come from physiology. This science, however, developed a tendency to keep at a distance from medicine on account of the inexactness of the latter. There is an improvement to be noted in this regard; there is a growing tendency in physiology nowadays to pay greater attention to medical problems. However, even if physiology and other related

[2] *Science*, Jan. 1, 1909, p. 5.

[3] Congress of Science and Art, 1904, V, 395; chairman's address.

medical sciences would devote all their time and energy to the study of purely medical problems, it would not bring about a radical solution of our perplexing problem. Neither will this be accomplished by the creation of chairs for experimental medicine. The regeneration or rather creation of a science of clinical medicine must come from the innermost of medicine itself. It is true, as stated before, that the men who are to tackle these problems must have a thorough training in the sciences allied to medicine, but the center of their activities must be within clinical medicine itself. They must have a bringing up within medicine, their minds must have been filled up with thinking, worrying, brooding over practical and theoretical problems of clinical medicine.

Let me recapitulate. There is a necessity for a differentiation of clinical medicine into a science and a practise. The clinical science has well-defined objects and is a most important department. It must be managed by a set of men specially trained for and almost exclusively devoted to that task. Without the development of such a department of clinical science the efficiency of the practise of internal medicine will lag behind, no matter how progressive the allied sciences of medicine are and how great their efforts to be useful to medicine may be.

The Conditions as They Actually Exist

In conjunction with the foregoing considerations let me glance at the conditions of clinical medicine as they actually exist here and abroad. I may state that neither abroad nor here do we find a separate class of investigators confining their activity solely to the domain of the science of clinical medicine. Everywhere science and practise of clinical medicine go hand in hand. We may, however, admit at the outset that there is an enormous difference in the status of medical research between abroad and here. Let us take the development and the present status of clinical medicine of the German-speaking countries as an illustration of the conditions abroad. We shall notice that there the mother stem of medicine managed to retain a scientific aspect despite all processes of differentiation.

When for the first time pathologic anatomy broke away completely from medicine and was taught by Rokitansky at the University of Vienna as an independent branch of medical science, we find that at the same time and at the same place the celebrated Skoda was teaching the remaining trunk of clinical medicine as a natural science, constructing

the methods of auscultation and percussion on a sound basis and establishing a firm connection between the *intravitam* diagnosis and the post-mortem findings. The purely anatomic tendencies of that celebrated school of medicine which unfortunately gave birth to nihilism in medicine, were soon curbed by the appearance of Virchow on the medical scene in Berlin. While also working for the establishment of the pathologic anatomy, gross and histologic, as an independent natural science, he manifested throughout his long life a deep interest in the development of clinical medicine on sound lines. At the very beginning of his brilliant career we find him stating (in the prospectus to the first volume of his *Archiv*) that practise of medicine should be an applied science and the ideal of the science should be a complete pathologic physiology. The great clinical contemporaries of Virchow strove for a similar ideal. Frerichs introduced chemistry and Ludwig Traube the methods of experimental physiology into the domain of clinical medicine. I shall not dwell here further on historical details. I shall only say that clinical medicine in Germany remained true to this ideal throughout all these years of marvelous growth of medicine. The exponents of clinical medicine in Germany are the flag bearers of pathologic physiology. The contemporary clinicians master the immense knowledge and manual skill which contemporary clinical medicine demands of its disciples, and nearly all of them are themselves diligently adding new facts to the store of medical science. I do not need to tell you the particulars. Some of you know from personal experience such master clinicians as Müller, Krehl, Kraus, Minkowsky, and a good many others like them. However, the standard of medicine is kept high not only by the heads of university clinics; the various members of their staffs, heads of hospitals and their staffs and a host of volunteer workers are continually digging for new fruit in the soil of clinical medicine. The medical literature is full of original, first-rate work in the science of clinical as well as of experimental medicine contributed by men whose main abode is clinical medicine.

Now there is in Germany no special chair for the science of clinical or even experimental medicine. All these contributors to medical science are in a sense simply medical practitioners. What is the secret of their scientific success? It is simply this: to these men science is the first and practise the second object of their life. To most of the leaders of medicine in Germany the tasks of gaining and diffusing knowledge

receive their first attention and the consultation practise comes in last. Again, these very leaders before they have acquired their commanding positions spent many years of their life in preparing themselves for it; in training in scientific methods, in acquiring knowledge in the allied sciences and in the science and practise of clinical medicine, living meanwhile on small incomes, having no private practise at all or having a practise too small to interfere with their life ambition. You can not lead such a life unless you are possessed by idealism and a scientific spirit. That is the key to their success. And when these men become teachers, they can not fail to impart this ideal spirit to their students. That is the way they themselves received it. But they received it also in the institutions of their early education, where sport and habits of millionaires' sons are not the factors which form the character of the youth. They received it from the people among whom they grew up, among whom the worth of the individual is not measured exclusively by a gold standard. They received it from the care and encouragement of the government which, no matter what its political ideals may be, never loses sight of the fact that the cultivation of science is one of the greatest assets of a people. They received it in the traditions of medicine of their country; even before the new era when medicine was all in a cloud of so-called natural philosophy, only the substance of medicine was all wrong, its spirit was all right.

That is the situation abroad. Now let us look at the development and the present status of clinical medicine in this country. At a glance one observes with amazement that nearly all the factors which favored the development of a scientific spirit in Germany are absent. However, I shall not try to enumerate all the shortcomings with which the development of medicine in this country had and still has to contend. There is no educational advantage in doing it and you are all familiar with the situation. On the coutrary, I take pleasure in pointing out the encouraging fact that, despite all the difficulties, medicine in this country gradually rose to a commanding position in many respects. It is an instructive and stimulating fact that the progress of medicine in this country was carried on through the efforts of a few high-minded men or groups of men who at various times transplanted the spirit prevailing abroad into this country. I shall, of course, not attempt to enter into the particulars of the history of this progress. I wish to refer briefly, however, to a few phases in this history. In the first important

phase, clinical medicine in America received an elevating impulse through the activities of a group of medical men who continued their studies in France, where they came especially under the influence of the famous clinician Louis. Statistical methods of observation of diseases and diagnosis by auscultation and percussion became, then, the chief characteristics of internal medicine in this country. During the second period, young American physicians pursued their postgraduate studies in Austria and Germany. They brought home a knowledge of gross and minute pathologic anatomy and an aptitude for the use of the microscope. Pathologic societies were started and the teachers of medicine began to give separate lectures on pathologic anatomy and to instruct in the use of the microscope as a clinical aid. The studies and teaching of these new subjects gave at that time a scientific flavor to clinical medicine. The last period covers about the three last decades with the contradictory results of which we are confronted to-day. Again, medical men went abroad for postgraduate studies and perhaps in larger numbers than ever. But what this high class of young medical men studied there now was no longer in the direct interest of clinical medicine; they trained themselves in the intricacies of the sciences of medicine. The results of the studies of this period were again of great benefit to medicine in this country; in fact, they were of greater benefit than ever. In a comparatively short period the special sciences of medicine, thanks to the activity of a brilliant group of men, have gained a strong foothold in this country; special chairs and laboratories were created in many schools of medicine for pathology, physiology, bacteriology, pharmacology and physiologic chemistry. The work which is being accomplished now in these laboratories compares favorably with the work done in the countries with older scientific traditions and much more favorable surroundings. However, by this very departure clinical medicine itself suffered a visible retardation in the development of its own department. I discuss this phase not with pleasure, but the truth must be said. To my mind it is a fact that the leading clinicians of this generation do not compare favorably with their predecessors in this country, not to speak of a comparison with the leaders of clinical medicine in other countries. One of the reasons for the retardation in the progress is the loss to clinical medicine of the brainy men who now devote their energies to the pure sciences of medicine. Another reason may be found in the fact

that by giving up pathologic anatomy and microscopy to special departments clinical medicine lost that part which has given it formerly its scientific character. An evident drawback to the progress of internal medicine in this country is the fact that its teaching at the present time is mostly still in the hands of men who received their medical training nearly exclusively in this country and at a time when pathologic anatomy was the exclusive basis and auscultation and percussion practically the exclusive methods of diagnosis. But in the last twenty-five years internal medicine changed its aspect greatly. The men who want to teach the medicine of to-day must have an education and training radically different from those which were customary and sufficient in former years.

However, the greatest evil of them all is the deplorable fact that in most instances internal medicine is taught in this country by very busy consultants who can give only a small fraction of their time and mental energy to this one of the side issues of their busy lives. Teaching medicine and furthering its science is a very serious business which ought to be carried on by men who are ready to devote all or most of their time to it.

Here are problems for you to solve. The progress of clinical medicine in this country has to be accelerated again. We might reach the level which we have seen to exist abroad. But we ought to strive to get still higher; in this field lack of modesty is a stimulating virtue. Look at the allied sciences of medicine, the level of which they have reached in a comparatively short time without any tradition and only through the activity of a small group of high-minded men. The progress of medicine in this country was always carried on by the few and not by the masses. Clinical medicine must reclaim some of the brainy young men who were enticed by the sciences of medicine. You represent a new generation. You have had an education and a training in modern medicine and the allied sciences. You have a training in investigation, the constitution requires it of you. The constitution which you have adopted shows your spirit. Among its objects is "the cultivation of clinical research by the methods of the natural sciences and the diffusion of a scientific spirit among its members." But you will accomplish more; the constitution imposes on you the obligation to be active in the diffusion of the principles of the society, particularly among the students who come under your charge. I would recall this obliga-

tion to the minds of the members who were called within this year to chairs of medicine at influential places. The constitution does not keep you down exclusively to science, but let me tell you: beware of practise. It is a bewitching graveyard in which many a brain has been buried alive with no other compensation than a gilded tombstone.

One last word. The men whom you now see sitting on the bank left behind while the boat of progress swiftly glides away with fresh winds and under fresh sails were themselves in their youth passengers of similar boats and cut faces at others who were left behind. Be generous to them, but do not repeat their mistakes. The secret is: never leave the boat.

THE PUBLIC AND THE MEDICAL PROFESSION[1]

By James Ewing, A.M., M.D.,

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To-night the New York Academy of Medicine enters formally upon the sixty-fourth year of its activities. It was in 1847 that one hundred and thirty-two New York doctors, led by John Stearns, A. H. Stevens, Valentine Mott and Isaac Wood, resolved to incorporate the higher interests of the medical profession in the New York Academy of Medicine. The objects in mind at that time were mainly three: (1) The unification of the regular practitioners of medicine, (2) the elevation of the standard of medical education, and (3) the promotion of the interests of medical science.

The strong ideals of those early days far outshone the modesty of their organization, for, as Dr. William Detmold recalled many years later, the early meetings of the academy were held in a dingy room over a coal yard in Wooster street; the social ambitions of the new institution were most meager; not even a beginning of a library was attempted; and the idea of a permanent building, which was sorely needed for the various uses of the institution, seemed and proved to be a far-distant dream.

The foundations of a permanent building fund were laid in 1853 when the surplus contributions of the doctors for the entertainment of the American Medical Association were set apart for that purpose. Yet it was only after an interval of twenty-two years and through oft-repeated efforts that in 1875 the academy was able to purchase a home at 12 West Thirty-first Street. A notable ceremony marked the occupation of this first permanent building of the academy, and the addresses on that occasion revealed what strenuous efforts and almost religious enthusiasm had been called forth in the endeavor to provide a great community with a home for its academy of medicine. The fervent pioneer spirit of the founders of the academy is well displayed in the words of John Stearns, who in an early address declared that if he could be assured of its uninterrupted and enduring prosperity in disseminating

[1] Anniversary address of the New York Academy of Medicine, delivered November 16, 1911. Published in the *Medical Record*, December 16, 1911.

health and happiness and the sustaining principle of life he would die in peace with effusions of gratitude and praise to Almighty God for his permanent blessings upon their labors.

It does not appear that the founders of the academy received or looked for any material support from the public. Both the fruitless and the successful appeals that in 1875 had accumulated $14,000 had been made exclusively by the three hundred members of the academy itself. Likewise in the further material growth which led to the purchase of the present site and has brought us to-day to the necessity of extensive enlargements of the academy building, the appeal has been, with a few noteworthy exceptions, to the medical profession itself. A glance at our sister communities shows that the history of the New York Academy of Medicine is being or has been reproduced in many other American cities. Everywhere the demands of the higher ideals of medicine lead to the creation of such institutions, and everywhere the appeal is met chiefly or wholly by the medical profession.

Throughout the long period of our material growth the intellectual activities of this academy have more than maintained an equal pace.

The 132 original members have been succeeded by the present membership of 1,280. While it is becoming less and less a mark of distinction to be a fellow of the academy, it is more and more a notable delinquency for an eligible physician not to become a member. The single section of the early days has expanded into a score of special bodies, each pursuing effectively its special field in regular conferences. The general meetings of the academy draw the most distinguished representatives in America of every branch of medical art. The interests of every branch of medical science are warmly supported by the authorities of the academy, and here have centered the activities of several independent medical organizations, some of which, as the New York Pathological Society and the County Medical Society, are more venerable than the academy itself, and our hospitality is sought by several bodies representing allied sciences and arts. Scores of distinguished visitors from abroad remember and many have recorded their welcome here. The records of the academy show that from the earliest days the best work and the best thought of the leaders in New York medicine have been presented at its meetings, and those who are familiar with the submerged history of the academy know that its life has always depended upon the unfaltering devotion of a long list of famous physicians who have planned and worked for its interests.

Yet the scope of the academy is not confined to the current activities of its various sections and allied societies. The library of the academy has been the special pride of many of the foresighted guardians of the past, and is to-day the second most complete collection of medical literature in America. It is freely accessible not only to the entire medical profession, but to the general public as well, and it is probably the most actively used collection of books in the world. It would be difficult to estimate the significance of the influence thus exerted, through the dissemination of knowledge, not only in all branches of the medical profession, but also in veterinary science, dentistry, biology and chemistry, and in the steadily enlarging scope of the layman's acquaintance with medicine. May we not pause and compare with pride the relative significance of this priceless collection of books stored in dark corners with that of our magnificent and aristocratic neighbor the New York Public Library?

The public services of the academy extend, also, to the consideration and support of the interests of hygiene and sanitation and many peculiar problems of sociology and public morals, which can be solved only through intimate acquaintance with their medical aspects.

Truly medicine is still the mother of the sciences, and the Academy of Medicine in New York has established itself as the home and guiding hand of all the influences which, according to worthy tradition and critical experience, further the realization of the ideals of the medical profession. It would be a worthy task, in which one might engage with enthusiasm, to fully sketch the history and present position of the New York Academy of Medicine, for this we believe is a fair reflection of the best type of medical enterprise. The profession is proud of the academy and asks that the leading motives of medicine be judged by the standards established here.

But I have only hinted at some of the conspicuous achievements of the academy in order to introduce the subject of this discourse, which is, not what estimate we place upon ourselves, but what conception the public holds of modern medicine.

Our distinguished president, in honoring me with the task of preparing this anniversary address, has doubtless acted in accordance with the growing tendency to dispense with an orator and an oration and to call on these occasions for a specific treatment of some of the many problems that confront us. Being thus relieved of the necessity of attempting a literary contribution, I have ventured to think that the present

somewhat delicate topic might well engage the attention of this audience. For there is no denying the fact that the public holds quite a different conception of medicine from that of the physician, that there is a growing distrust of medical practise and an increasing dissatisfaction with its results, that disclosures of grave defects in the standards of medical education, which we freely admit, have mystified the public and raised a serious suspicion regarding the general competency of practitioners, that increasing specialization and the increasing cost of medical services are misinterpreted, and, above all, that the striking achievements of the mechanical arts, the increase in wealth and luxurious living, have rendered more conspicuous than ever before the uncertain tenure of human life and the incompetency of modern medicine to control the great majority of diseases. In the presence of these obvious conditions, which every order of intelligence can appreciate, there is perhaps little wonder that the public passes with perfunctory notice the brilliant conquests of preventive medicine, ignores the rapid advances in the general knowledge of biology, physiology and pathology, and permits an event like the discovery of *Spirochæta pallida*, an agent that has had a very profound influence on human history, to pass without even the faintest sign of public attention.

It is not intended to suggest that all educated laymen are unfamiliar with the true progress and achievements of modern medicine, but it is nevertheless true that prevailing public sentiment is out of touch and out of sympathy with us. This is seen in the crude and halting manner in which medical topics are handled by distinguished writers, clergymen, lawyers, statesmen and public officials. It appears in the garbled references with which the most inspired of the press condescend to honor us and misinform their readers. It shows in the liberal public support of all manner of medical cults, in the wide extension of the christian science movement, and in the wavering front of legislation, which no longer stands as a firm defense of the public health against the depredations of irregular and incompetent practitioners of medicine. Even the trustees of a great university yield to the allurements of a questionable interest, backed by a paltry sum, which seeks to encroach upon a most delicate and difficult medical specialty. Quite significant it appears also that the stage lends itself to our disapproval, by burlesquing the discovery of a most notable and beneficent addition to modern therapeutics, and garnishing the entertainment with catchy reference to the

dilemma which every doctor faces when he charges a fee for saving human life. Truly the wide extent of this public distrust must be acknowledged, the grounds for it should be carefully analyzed, and we must soberly ask the question, Is the medical profession doing its full duty to the public? James Russell Wallace once said, in effect, that an institution once established may come to be the chief obstacle in the way of the satisfaction of the need for which it was established. Wallace made this criticism of the church. Does it apply to medicine? Have we stood too confidently on the record of progress of the last sixty years, for modern medicine is only about sixty years old, and failed to realize that even greater achievements were within our reach; have we pursued science too much for science' sake and too little for its influence on human life; has the old, almost sacramental and heroic character of medical service fallen before the advance of commercialism; is the Hippocratic oath still the standard of medical ethics; is medical science, as the chief influence which makes for the subordination of physical evil, acquitting itself well in this day and generation, or are other sciences and professions outstripping us and do we deserve the disaffection and diffidence with which, on the whole, public sentiment regards us?

I can only offer some general considerations that bear upon these broad topics, and in doing so it is frankly acknowledged that I appear as an advocate in defense of medicine, and even with specific charges to prefer against the public, and I think this course may be justified on the ground that good may come from a frank statement of what the public owes to the medical profession.

In the last analysis the public disaffection with medicine rests upon an inherent defect of the human mind which opposes correct thinking along medical lines. When one reflects that even the leaders of medical thought for more than a thousand years passively bore the yoke of Galen's crude conceptions, of the pneuma, and the four cardinal principles of the body, blood, mucus, yellow and black bile, conceptions that correspond to nothing of importance in physiology, and that these conceptions held sway at the height of the development of Greek and Roman literature, law and philosophy, it would seem that the human mind is constitutionally unfitted for the grasp of biological principles. In this quality the public intelligence of to-day has advanced but little over the standard of the ancients. Whether it be from mental deficiency, or from a deeply rooted remnant of superstition so rife in all common

people, or from a possible narrowing influence of a portion of the church, or be it the educational system of the last centuries with its schooling in rigid mathematics and speculations in philosophy, whatever the cause, the modern mind is unfitted to grasp the idea of the marvelous delicacy and infinite variations of biological processes, and, therefore, it does not understand medicine.

Consequently, throughout its entire history, medical science has occupied an isolated position apart from the better understood and more cordially approved pursuits of mankind. It was not alone in punishment for his fatal results that the medieval surgeon had to leave town after each operation and lead the life of a nomad. It was a truthful expression of the public doubt of the honesty of the calling of the surgeon and a superstitious fear that the successful physician worked by supernatural methods. Naturally the protection of the church was a ready resort of the physician, and medicine and ecclesiasticism long worked in a certain harmony, medicine always shielded by the cloak of the priest. This unnatural union, enforced by public sentiment, led to the centuries of reliance upon the healing power of the saints and their relics, a situation distinctly fitting the public taste, but it led to the suppression of rational thinking and experiment, things which did not suit the public taste. Accordingly Friedrich Müller says that "The darkest periods of decay in German medicine were those in which philosophical speculation and theological mysticism obtained a preponderating influence over medical problems."[2] As degenerative phases of this movement we have the long history of sorcery, necromancy, astrology and alchemy, all of which flourished in response to the demand of an uninformed public sentiment. The church has been held responsible for much of the suppression of medieval medicine, but from this point of view it might appear that the public and not the church was essentially at fault. The dissection of the human body, needless to say, was distasteful to public sentiment and the foundations of human anatomy had to be laid while the public were protesting. The antivivisection movement throughout its long history falls in the same category of public movements founded on misconceptions of medicine. The conflict between science and religion was another expression of the same tendency. I believe that careful historical research would reveal many familiar facts of history which could be cited and interpreted to show that the public has never understood its contemporary medicine.

[2] Royal Commission on University Ed[illegible]

Would it not, therefore, be good policy if the more enlightened public of to-day should analyze the grounds of its disaffection and make sure that history is not repeating itself and that persistent traces of the old prejudice do not lie at the bottom of the current distrust of medical institutions? Only a few months ago thousands of excited people gathered around the relics of a departed saint in the eager hope of receiving some of their supposed healing virtue. There are many sides to the significance of the christian science movement, as William James has shown, but so far as it is an intelligible doctrine, and not mysticism, it rests chiefly on ignorance and distrust of medical science. We must confess that the public patronage of the numerous medical cults is logically due to the failure of medicine to deal successfully with a host of minor ailments. Physicians can well afford to yield to osteopaths and hypnotists the immediate concern with a long list of self-limiting functional disorders, but the public can not afford thus to intrust to any but physicians the early stages of serious disease. Here the public makes the further blunder of ranking with serious interests of medicine that host of abnormal sensations, some of them painful, which fall to the lot of the overfed and the indolent.

The most familiar sign of the public misconception of medicine is displayed in the efforts of the daily press to furnish information on medical topics. With rare exceptions these efforts consist of sensationalism, personalities, wonder-tales, absurdities, and a general display of the haste and incompetence of the writer. Every medical article written for the public press should first be submitted to a competent medical expert for revision. More pernicious still is the influence of a score of semi-medical journals which cater to the taste for misinformation and absorb a large portion of the $50,000,000 paid annually in this country in the advertisement of quack medicines.

The public has heard that medicine is highly specialized, but has not yet learned that specialization does not immediately transform the average general practitioner into a highly competent expert in a narrower field. The clever lawyer still takes pride in demonstrating that the experienced manager of an insane asylum may not be an expert in psychiatry. The courts accept practically any holder of a medical degree as a trustworthy authority in any department of medicine with which he chooses to claim acquaintance. It is very rare to find even an educated layman who understands that the medical sciences stand some-

what apart from practise and that they comprise a numerous group of highly specialized branches, each requiring peculiar training and attainments. For the educated public the opinion of Robert Koch is only in a vague way a little better than that of their family doctor, while the uneducated public does not concern itself with the opinions of scientists. Here is the great dilemma. Medicine is like the iceberg, seven eighths of which is submerged, but the public must of necessity form its estimate from the visible one eighth.

Not having understood medicine, public sentiment has never given it adequate material support. That support has come from enlightened governments and from men of large means and discerning minds. The numerous private endowments of medical philanthropy and research in this and other countries stand as a conspicuous ornament in modern life. Yet these gifts have come from isolated sources, they are usually impelled by the occurrence of some tragedy in the family of the donor, only in a few notable instances have they arisen from a clear conception of the needs and deserts of medicine, and they do not constitute uniform and adequate public support. Even in this, which is the best expression of the public conscience, too often the institutions have been isolated, diminutive and ineffective, and it must be feared that occasionally they have served chiefly to exploit the donor and the donor's physician. It is clear that the type of almsgiving counseled in the Sermon on the Mount does not meet the exigencies of modern life. Medicine can not afford to rely too much on the generosity of public-spirited citizens. It is, therefore, a significant sign and an honor to the intelligence of our western states that their legislatures have adopted the policy of caring for medical education and research. A considerable volume of public opinion is back of this policy and the western people are proud especially of the assured future of their universities. To what extent medicine will flourish under these auspices remains to be seen, but at present the west as well as the east has a wholly inadequate idea of the scope and cost of medical education and research.

Perhaps the surest expression of public sentiment is found in the character of its legislation. I think it must be said that the laws of the land protect the medical profession better than the public. There has been a notable disinclination to restrict the rights and privileges of the regular school of medicine, but there has been, on the other hand, an ill-considered expansion of the privileges of irregular prac[illegible]

semi-medical cults. In this liberality the public sees only adherence to our traditional ideas of freedom, but it does not see at what cost of life it has legalized the treatment of all sorts of disease and the signing of death certificates by uninstructed persons.

In the adoption of the measures which medical science has demonstrated as necessary for the protection of public health most American communities are delinquent. There is not a single active school of sanitary science in the country, not because the universities have not tried to establish them, but because there is no demand for them and there are no students. Therefore, the sanitary laws of small communities are enforced by persons who are often interested in their infraction. In many cities typhoid fever has been epidemic for years, although these communities were fully able to build water filters. Medical science has pointed the way almost to the complete suppression of tuberculosis, but tons of tuberculosis beef are marketed in New York daily, and the average dairyman thinks his opinion of the tuberculin test in cattle is quite as good as that of the German government. It is said that the inhabitants of southern states generally resent the gift of a million dollars to build sanitary waterclosets and help rid them of the hook-worm. Indeed, it is the usual experience for the public to resist the introduction of sanitary measures, so that it has been necessary for medicine not only to perfect these beneficent measures, but also to bind the beneficiaries hand and foot in order to administer the remedy.

It is not alone the pressure of politics or the eccentricities of the law which delay the formation of at least one institute of legal medicine in this country. It is the general failure to appreciate that a high development of this branch of medicine is essential in a well-ordered community. The national government has at last awakened to the necessity of a national bureau of health, such as has long existed in other civilized countries. Yet instead of going ahead with it we have the astonishing spectacle of the president of the United States holding a public hearing to debate the question. Finally public sentiment still permits the health commissioner of the state of New York to be replaced every few years according to the rules of political patronage, and with Asiatic cholera at our doors we have just witnessed the distinguished health officer of the port of New York subjected to an investigation by a medically uninformed jurist to whose mathematical mind the control of an epidemic must be "either efficient or inefficient."

Such is a partial catalogue of the delinquencies which modern medicine charges up against the modern public. In enumerating them I fully realize that they relate chiefly to deep currents of opinion, thought and custom, which move with great momentum and are beyond the control of pure authority. Yet they do not concern isolated eddies in the current of opinion, but fairly reflect the general tendency and color of public feeling. Certainly there is here enough undigested food for thought to fully occupy the attention of the layman and to call for a concerted effort to render public sentiment more considerate of its plain responsibilities. To quote again from Wallace, "the nineteenth century added to the sum of human knowledge more than the previous ten, but did less than any other to make its knowledge available for human needs." Medicine has done its duty to the public, but the genius of medicine is not understood and the problems which medical science has laid at the door of the modern world have not been adequately acknowledged.

There are other duties besides those which we are obliged and enabled to perform because of the general progress of knowledge. The modern spirit of service demands that medicine shall not over-emphasize the achievements of the past, but should adequately prepare for the future. The objects for which this academy was founded are just as urgent to-day as in 1847. The unification and morale of the regular profession rightly engage our constant attention, and, while we acknowledge the justice of outside criticism of the streaks of commercialism and veins of mutual distrust which may afflict us, strong internal forces are at work to combat these tendencies. No commercial physician escapes detection and the right estimate by his fellows, and medical opinion places a far higher value upon just valuation than upon clever criticism of the work and attainments of one's colleagues.

Medical education is the most earnestly considered problem before the profession to-day. The astonishing changes that have occurred here during the last two decades in America have been approached in no other field of human endeavor and stand as a monument to the honesty and intellectual vitality of the American medical profession. As a feature in this progress the fourth report of the Carnegie Foundation, which was delivered without fear, has clearly stated the situation and hastened many desirable changes. Incidentally this report carries a message of great significance to the public, since it shows that the so-called

regular profession is the only body seriously engaged in medical education and research, all the medical cults which the public loves to patronize standing before that bar of judgment empty-handed or worse.

The third object of this academy and the duty of the entire profession which it represents is to further the interests of medical science, and it remains as the last part of the plan of this discourse to inquire whether we have done our duty to the ideals of medical science. In making this inquiry we pass far from the ground of common-sense judgments to the field of ethical ideals, but a large part of medicine lies in this latter territory. In these days when the word research is on every man's tongue, when journals teem with titles purporting to relate to new facts in medical science, when the attention of men of means is successfully directed to the results attainable in this field of philanthropy, it might seem to be a difficult and useless task to argue that the medical profession does not adequately support medical science. Yet this is just the judgment which, with much caution and reserve, I would venture to maintain this evening. I hasten to acknowledge the brilliant record of American men of science in medicine, the long list of notable discoveries and fundamental contributions that represent the best product of American brains. As a pathologist I take pride in belonging to that branch of the profession that produced Ricketts and a score of European martyrs to science. It is true also that a somewhat extensive machinery has been set in motion in this country with the idea of enlarging the scope and raising the standard of our scientific work. There is much to the credit side of the account. Yet a clear conception of the meaning of medical research, the physical conditions under which it can thrive, the organization of institutions that can supply the training and the men, a true estimate of the value of scientific attainments and tendencies in the medical practitioner, in fact a systematic attention to the demands and ideals of medical science are not highly developed in this country, and in this respect medicine, having discharged its duty to the public, is delinquent in its duty to itself.

Having, in a sense, closed the doors to our public critics, I beg leave to briefly state some of the grounds on which this feeling is based.

The misconceptions of the nature of medical research take very numerous forms. One of the most curious was embodied in a recent public document recommending the introduction of the methods of the department store into scientific laboratories, as though, as one commenta-

tor retorts, the discoveries of a Newton could be called for at a certain day and hour, or that the scientist's mind should run chiefly in the line of the card catalogue of trivial events. Quite rife is the idea that research consists in extracting the European mail, repeating the experiments one finds there, and publishing the results without full acknowledgment of their inspiration, or, what is little better, with a few additional facts which are chiefly dependent on accidental conditions. Many think it necessary to point out minor faults in fundamental contributions, but I very much doubt if such activities are ever worth while. To set oneself the specific task of demolishing the conclusions reached by careful observations of one's colleagues is seldom a necessary step in progress. Agassiz advised "Study nature, not books." Some investigators announce as many as twenty or even thirty titles of original studies in one year, but Theobald Smith said "the real progress of medicine is covered over with a froth of research through which only a few great minds are capable of penetrating." Opinions differ as to what methods of announcing the progress of research are consistent with sound judgment and a sterling devotion to the best ideals, but there are those who deplore the strife for priority, who distrust the preliminary communication, and who believe that a man is an unsafe man in so far as he is looking for prompt recognition of his contributions to medical science. I mention these somewhat distasteful matters because the opportunity to study carefully the mysteries of disease and to publish the essentially new results at the proper time and in a dignified manner is not so common as some of us may believe. Few would care to offer a definition of genuine medical research, but I think I see examples of the true spirit in men who are very sensitive to the unknown in the medical conditions they meet, who feel a certain moral responsibility toward the solution of problems, and who are willing to spend some or all of their time in the solution of these problems. This type of research is open to every member of the profession.

The discovery of *Spirochæta pallida* was a sensational event, coming apparently out of a clear sky. Yet even here there were several preliminary steps which made this discovery possible. A series of fundamental contributions, usually from many sources, almost always precedes a great discovery, so that the final step is a perfectly logical result of antecedent factors. Are we not inclined to underestimate the value of fundamental contributions in the haste to create medical heroes on the

basis of supposed single-handed discoveries? Some find it their function to plant the root of knowledge and cherish the growing tree over many barren years, while others delight to pluck the fruit when it is about ready to drop. It is significant that the credit for great steps in the progress of knowledge can seldom be narrowly placed.

The physical conditions that surround the interests of medical science in this country are comparatively unpropitious. When the financial rewards of most other lines in medicine are distinctly alluring only a vein of eccentricity or idealism can induce a young man of ability to enter a career which assures a comfortable living for but a few fortunate leaders. The president of a great university recently openly announced that it was necessary to fill the ranks of the medical sciences with such eccentric persons who could get along without a decent living, and this is the tacit policy of all American medical schools. As a necessary result, the quality of brains that enters the medical sciences in America is of the nonconformist type and in certain respects is inferior to that which enters practical medicine, but I hasten to add my belief that the superior intellectual life and scientific methods of the laboratory may enable the inferior man eventually to outstrip his more gifted colleague.

In America we boast of our material resources for medical science, but in reality they are far inferior to those available in Germany and France. The Germans paid Waldeyer 140,000 marks a year at Strasburg, besides student fees, but there are very few positions in America which permit a scientist to live in a city house and raise a family. Money rewards do not attract the genuine investigator, but until the endowments of research are on a wholly different scale from the present the true possibilities of American medical science will not be realized.

The organization of our medical institutions could hardly be worse for the progress of science. The three main activities, the care of the sick, the education of physicians, and the search for new facts, have grown up in isolation, although every one recognizes that each is dwarfed without the others. The complex factors which stand in the way of successful reorganization have been clearly stated by recent writers and the public conscience is slowly awakening. The medical schools are beginning to see that they are quite as much responsible to medical science as to medical education, and at least one school is being founded with this responsibility chiefly in view. It becomes increasingly difficult for the busy practitioner to meet the demands of a great depart-

ment in a university, but he can perform an honorable service by surrounding himself with young men who have been trained in the sciences upon which his specialty depends for progress. The time has come when those who aspire to a university career or distinction of any kind in the clinical branches must serve an apprenticeship in the medical sciences instead of in the personal service of the influential doctor.

The interests of medical education are in the hands of several very able bodies and its innumerable and very complex problems have been discussed with much care and discernment. Yet I believe that the trend of this discussion indicates that the American profession underestimates the claims of medical science as an ideal in education. Everything is being swept aside in the effort to provide the student with premature clinical experience. We shall doubtless turn out the most adept practitioners in the world, as we do dentists, but dentistry is almost sterile as a science and relies on medicine for its chief progress. It is to be feared that the new curricula discriminate too boldly against that broad acquaintance with the medical sciences which alone can maintain the standards of the profession. We discriminate against knowledge more than Germany undervalues practical ability. We are not yet willing to pay the price of mature and effective clinical instruction, for that price is a fifth year in the medical curriculum.

In the years 1800–1810, or longer, a leading hospital in New York devoted funds to the purchase of expensive medical books and maintained a library for the use of its staff. The trustees seemed to feel a responsibility to medical science. That library has been dissipated and the hospital is now run on strictly business principles. Yet there is venerable precedent for the support of medical science by our great hospital endowments, and it has been made clear to the slumbering conscience of the hospital trustee that he has long been gravely delinquent in an important duty. It will be a notable event in the history of American medicine when that conscience is fully roused to action and when, overcoming every obstacle, there is effective cooperation between the immense resources of our hospitals and those of the universities.

That there are contrary opinions regarding the value of scientific training to the practitioner merely shows how vague is the general conception of laboratory science. It seems to me that this is the most discouraging side of the present outlook for medicine. It is chiefly responsible for the gulf which separates medical science from medical

practise, and it accounts for a vast number of the occasions when the right thing is not done at the right time at the bedside. It substitutes empiricism for carefully tested opinion. Not being familiar with the methods and limitations of laboratory technique, the practitioner readily acquires a confidence in the infallibility of diagnostic tests, of which the dead far outnumber the living. Or he affects complete distrust of the whole field of microscopical and chemical diagnosis. It remains the great function of the clinical observer to discern many of the problems of medicine and to suggest to the laboratory those that may be solvable, but this function can be performed only by one who is acquainted with the methods and capacities of laboratory science. Scientific training adds class to the quality of a medical practitioner, and whether we like it or not it is a fact that the well-trained man is the productive man in his field and is steadily replacing the untrained. Competition in clinical preferment has not yet reached with us the stage when a record of productive work is essential, but that day is not far distant, and I venture to predict that it will come suddenly and to the sore discomfiture of many of the confident detractors of the value of laboratory training to the practitioner.

Thus several of the most vital interests of medical science suffer from very conspicuous defects in the present support and even in the future plans of the profession. It is not too much to say that medical science flourishes with us in the face of unnatural hindrances, many of which it is within the power of the profession to mitigate or relieve. Some of the conditions would not be tolerated for a moment in the industrial world, and others, such as the obstacles to the scientific development of our hospitals, are incompatible with a plain sense of honor. In certain aspects, as Wallace suspected of the church, the inertia of our medical institutions and traditions stands in the way of the satisfaction of medical needs. I venture to say that the settled policy of this academy should involve a systematic campaign in support of the larger interests of medical science. Twenty years ago Max Nordau predicted that in a quarter of a century American medicine would outstrip the world. I fear he is disappointed. We began too late and there are only five years left. Yet five years of the right kind of effort would make a vast difference in the complexion of medical institutions in America.

And finally, may we not anticipate some of the rewards of faithful devotion to the ideals of medical science? We love to dwell on the past

conquests of medicine, in the control of epidemics, in the rendering habitable of the uttermost parts of the earth and the slums of great cities, in the triumphs of surgery on which we drill the public, in the immense advances in chemistry, physiology and pathology, and in the creation of many new branches of medical science, all of which have combined to add twenty to twenty-five years to the average tenure of human life, but one may listen to this rehearsal without a particle of emotion when one considers the greater problems that still confront us. The fruits of the germ theory have enabled us to prevent infectious diseases, but our capacity to cure them is extremely limited. In the knowledge of diseases of nutrition and metabolism hardly a beginning has been made. Of the ultimate nature of the physical and chemical processes upon which life and animal functions depend we possess only vague surmises. Before the long list of natural diseases of the animal kingdom we stand as helpless catalogers of superficial phenomena. Medicine is still in its infancy. Comparative medicine is a pigmy opposed to a colossus of unmeasured proportions. Considering the vast scope of its problems, the activities of our anti-cruelty societies, which are the pride of many, appear as idle splashings on the water's edge of the ocean of animal suffering, while the real depths of that ocean are being sounded by the workers in comparative pathology. One can review only with horror the brutal forms of parasitism and the merciless laws of natural slaughter and death that prevail among the lower animals. It was an observation in natural history when Isaiah said, "They shall look unto the earth and find darkness, dimness of anguish." For we are charged with the whole task of mitigating physical evil throughout the entire animal kingdom, and our human interests, as we are beginning to see, are inextricably bound up with those of the lower animals. We must accept the hope that nature herself shall some day be redeemed. Medicine is clearly marked as the chief instrument in that redemption and only in the light of this destiny can her true dignity be realized. How then can we rest, even for a moment, on the achievements of the past?

Every period in the progress of medicine is marked by opportunities which render it more significant than its predecessors. At the present time, while no new era in medicine seems imminent, the opportunity for the successful application of known principles to practical questions is unprecedented. No medical heroes rule with unquestioned authority to limit the freedom of thought and action of the host of competent work-

ers in every land. The original germ theory has served its purpose well and descriptive bacteriology is being succeeded by the study of the contributing causes of bacterial diseases and of the factors which control the incidence and distribution of microorganisms. The doctrine of anaphylaxis, or increased and specific susceptibility to the action of chemical agents, promises to carry us far more deeply into the mysteries of disease than any previous contribution to pathology. The application of known medical principles to problems in sociology and in the prevention of chronic and hereditary diseases offers an immense field for the future activities of medicine. The great significance of the organs of internal secretion is being more clearly recognized and the revolutionary influence which this department of physiology seems likely to have upon the medicine of the future is in no sense belittled by the imperfections of our present knowledge. The science of nutrition seems to have entered upon an era of permanent progress, based upon the carefully attested data of the physiological chemist. The last decade has seen the science of eugenics take definite form, that science of the future which looks toward the day when every child born can be assured of a sound mind in a sound body. Experimental morphology and the studies of heredity warrant great hopes in this untrodden territory.

No one would prophesy which fields may prove most quickly productive, for all our problems are eventually solvable and time is of minor consequence before the steady advance of experimental science, that instrument to the power of which Pasteur saw no limitations. History justifies the fullest scope to the scientific imagination, for the miracles of yesterday are the commonplaces of to-day. It is a grave duty and a high privilege for every physician to see that his influence, in whatever capacity, tells for the realization of the ideals of medical science. For we look for the day when the cry of the innocent victim of disease, be he man or beast, shall be answered, and when the maladjustments of a vicious nature shall be coerced and corrected by human intelligence.

THE DUTIES AND RESPONSIBILITIES OF TRUSTEES OF PUBLIC MEDICAL INSTITUTIONS[1]

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The value of occasional and stated gatherings of the principal leaders of medical thought in the various special departments is acknowledged by all. Certainly those who have attended this congress, now held for the sixth time, have felt its broadening influence. We are apt to become narrow when we are devoted heart and soul to one specialty, be it medicine, surgery, physiology, ophthalmology, or any other. When we meet nearly all of the more prominent men in cognate and interrelated branches of medicine in Washington every third year, we are sure to find that there are as interesting and as important questions in other specialties as there are in our own; and, moreover, we are sure to find that there are men of as acute intelligence, wide reading, and original thought in other than our own departments whom it is our pleasure to meet, and whose acquaintance becomes not only valuable for what we find them to be, but because of the stimulus that they give to our own thoughts.

Ordinarily the presidential address has been devoted to some special professional topic. My first idea was to select such a subject for tonight, but as I was in India when I received the very highly appreciated notice of my election as President I asked the members of the Executive Committee for suggestions, being sure that their united judgment would be better than my own. I was very glad when they proposed the topic upon which I shall address you, partly because it is different from the usual type of such addresses, and partly because it seems to me appropriate to the present time. I shall, therefore, give the time at my disposal to presenting to you some thoughts on "The Duties and Responsibilities of Trustees of Public Medical Institutions."

[1] The Presidential Address at the Sixth Congress of American Physicians and Surgeons, Washington, May 12, 1903. Published in the *Transactions of the Congress of American Physicians and Surgeons*, 1903. [I have put brackets to the footnotes now added to show that they did not appear in the original address.—W. W. Keen.]

Before entering upon my topic I beg to state explicitly that what I will say is offered in no spirit of unfriendly criticism, but only by way of friendly suggestion. I have been too long and too intimately associated with scores of such trustees not to know that they are almost without exception generous, self-sacrificing, giving of their time and money and thoughtful care without stint, and often sacrificing personal convenience and comfort for the good of the college or hospital which they so faithfully serve. Anxious to discharge their trust to the best of their ability, I am sure they will accept these suggestions, the fruit of forty years of personal service as a teacher and a hospital surgeon, in the same friendly spirit in which they are offered.

There are two such classes of institutions to be considered: (1) Medical colleges and (2) hospitals, whether they be connected with medical schools or not.

There is, it is true, a third class of trustees for a wholly new kind of medical institution which has arisen as a modern Minerva Medica, born full-armed for the fray. Of this class we have as yet but a single example—the Rockefeller Institute for Medical Research.[2] Akin to it are laboratories for special investigations, such as the two cancer laboratories in Buffalo and Boston.[3] But the Rockefeller Institute is so recent, and its scope at present necessarily so undetermined, that I would not venture to consider the duties of these trustees, and I am sure their responsibilities are adequately felt by them. Moreover, their admirable selection of a Director for the institution is the best pledge of a future wise administration. I heartily congratulate the profession and America upon the establishment of so peculiarly useful an Institute. Its founder has wisely left its work unhampered saving as to its general purpose, and the whole world, and especially the United States, will soon be his debtor for researches and discoveries that will abridge or even abolish some diseases, shorten sickness, prolong life, and add enormously to the sum of human happiness. Could any man of wealth by any possible gift win for himself a higher reward or a happier recollection when he faces the future world?[4]

Though not a medical institution, I can not refrain also at this point from expressing not only for myself, but for you, our hearty apprecia-

[2] [The Memorial Institute for Infectious Diseases in Chicago had just been founded.]

[3] [Other similar laboratories have since been established.]

[4] [How completely and how splendidly this prediction has been fulfilled!]

tion of what the Carnegie Institution has done for medicine in the reestablishment of the "Index Medicus." This publication is essentially and peculiarly American in origin, but its usefulness is world-wide. It aids alike an author in Japan, or in India, in Europe or America. It is one of the best and wisest undertakings of this lusty educational giant. But to ensure the permanent publication of the "Index Medicus" the profession must show that it really values this generous gift. Unless the "Index" finds a hearty support in the profession abroad and especially at home, we can hardly expect the continuance of this unique and invaluable publication. May I earnestly ask, therefore, of this audience of the chief medical authors of the United States that each one will demonstrate his appreciation by an immediate subscription to the "Index Medicus."

There are some matters common to both the medical college and the hospital which may be considered together. The most important of all these is the cordial and hearty cooperation of the medical men connected with the college or hospital and the boards of trustees. In order to ensure this the members of each body must be acquainted with each other. I have known of instances in which, if a professor in the medical school ventured to suggest any changes as to its management, or even to state his opinion as to the qualifications of a candidate for a vacant professorship, his suggestions were resented as an interference, instead of being welcomed as a means of valuable information. I take it for granted that we should not offer such suggestions after the fashion of a partisan either of a man or a measure, for the advancement of a friend or to the disadvantage of an enemy, but solely for the good of the institution with which we are connected. He who would endeavor to foist a friend upon an institution *because* he is his friend, and in spite of the fact that a rival is the abler man, and better fitted for the position, is just as false to his duty, to his college, or to his hospital as the trustee who would vote for the less desirable man on the ground of personal friendship or of association in some society, church or other similar body. Of all these influences, that arising from membership in the same religious body is, I fear, the most frequent and yet most absolutely indefensible. What one's theological opinions are has no more to do with one's qualifications for a professional or hospital appointment than his opinions on protection as against free trade, or whether Bacon or Shakespeare wrote Hamlet.

I have always honored one of a board of trustees, who was an old personal friend of my father's and who had known me from boyhood, yet who in my early professional career, when I asked for his vote for an important hospital appointment, had the manly courage to tell me that he thought a rival, who was older and more experienced, was the better man for the place and that he should, accordingly, vote for him, and not for me. I confess it was at the time a bitter disappointment to me, but I never had so high an opinion of my father's friend as after he denied me his vote and I lost the appointment.

There should be, in my opinion, but two questions asked in considering the election of either a professor or a hospital physician or surgeon. First, which one of the candidates for the place has the best qualifications from the medical point of view? This should include not only his scientific knowledge, but his ability practically to impart or to apply that knowledge. Secondly, are his personal qualifications and character such as to make him a desirable incumbent of the position? It must be remembered that a man may be scientifically and practically an extremely able man, but of such a quarrelsome disposition, or the unfortunate possessor of some other similar personal disqualification, as to make him a most undesirable member of a staff. The personal equation may be quite as important as the scientific qualification. Of course, his personal moral character should be above reproach. To place a drunkard or a libertine in a position of so much responsibility and influence is to abuse a trust. No patient should be confided to the care of such a man, and still more no such man should be made an instructor of young men, upon whom his influence would be most disastrous.

It is often extremely difficult for a layman to reach a correct conclusion as to the qualifications of medical men for college or hospital appointments, because of the confident, yet conflicting, statements of their friends. But there is apt to be a certain clear partisanship in such statements which betrays the purpose of the speaker. Especially will this be so if he advocates the election of A or B on the lower grounds of friendship, social position, or for other similar motives. The man who is advocating the best man because he *is* the best man has the stamp of sincerity upon every word.

Perhaps the most striking example I can adduce of such an unfortunate misjudgment is Dr. S. Weir Mitchell, who was denied a professorship in both the medical institutions of his native city, thus

depriving them of the most brilliant medical genius that America has produced within my personal recollection. For him it is now a matter of indifference, and for American literature it has been a gain. But for medicine, and especially for physiology, it was an immense loss. Both of his rivals were estimable, worthy gentlemen who held an honorable position in the profession, it is true, but Mitchell is a genius. "Eclipse was first; the rest were nowhere."

One of the best methods of bringing the medical board and the board of trustees into more intimate contact would be to have the dean or a committee of the faculty, or, in a hospital, if the staff is not too large, the whole staff invited to the meetings of the board. Here I can speak from personal experience. At the Orthopedic Hospital and Infirmary for Nervous Diseases in Philadelphia there are three surgeons and three physicians. These members of the medical staff are invited to meet with the board of managers at each monthly meeting, excepting the annual meeting, when the medical staff is elected. They are free to express their opinions on any topic relating to the management of the hospital to which their judgment may contribute something of value, but when a decision is taken they have no vote. It is purely in an advisory capacity and for the purpose of giving and receiving information that they are present. The plan works exceedingly well. When economy is necessary in the hospital, the staff is fully acquainted with the fact and can cooperate with the trustees; when expenses have run up from carelessness in the wasteful use of dressings or applicances, a halt is called; when, alas, very rarely, the treasurer is all smiles, and plans for the extension of the hospital, or the installation of some new addition to the plant is contemplated, their knowledge as to the necessity, for instance, of a hydrotherapeutic or an *x*-ray plant, or a new operating-room, is of the greatest possible value. Nothing but good, in my opinion, can come from such personal cooperation.

One of the difficult questions which boards of trustees have to face is whether there shall be a fixed age at which a college professor or a hospital physician or surgeon shall retire from the active duties of his post. I firmly believe that they should fix such a retiring age in the interest of the students and of the patients. As age advances, a man's opinions and his practise become "as petrified as his arteries." He is incapable of constant study, of adding to his knowledge or of keeping up with the feverish strides of medicine. He ought then to be relieved

of his cares and his duties. If no rule exists, he is allowed to continue his inefficient or even disastrous work, or by some harsh suggestion is compelled to give place to another more competent man. A rule is a condition accepted when he is appointed. In the army and navy, when an officer reaches 64 or 62 years of age he is retired on reduced pay, and because it is a rule he does not feel hurt or humiliated. So in a college or a hospital, when time and the rule bring us to the period when we must gracefully retire, no one's reputation is injured or his feelings lacerated.

I have ascertained that the following rules are in force in some of the larger institutions:

At Harvard, the age when a professor may request to be retired is 60, provided he has been in the service of the university for 20 years, with a reduced pay ranging from one third to two thirds of his salary. At 66 he may be retired by the President and Fellows partly or wholly. The details of the plan are admirably arranged.

At Chicago, while no plan is yet in force, largely, I presume, because of its recent establishment on the present basis, such a plan will soon be made operative.

At Columbia the retiring age, after 15 years of service, is 65, either at the request of the professor or upon motion of the trustees, and on half-pay.

At Yale the retiring age is 65, after 25 years of service, and on half-pay, but the retirement is not compulsory. It will probably be made compulsory before long.

At Cornell the retiring age is 70, but the pension fund will not be available until 1914. The retiring pension will then be $1,500.[5]

At the University of Pennsylvania and at Johns Hopkins no retiring age is fixed.

The only hospitals I know of in which a retiring age is fixed are the Massachusetts General Hospital and the Boston City Hospital. At the former the compulsory retiring age of the surgeons is 63, and of the physicians, 65. At the Boston City Hospital the visiting surgeons are retired at 65, but the physicians, gynecologists and all the other medical officers continue in service indefinitely—a very curious anomaly.

These varying, but in the main identical, provisions, when any exist,

[5] [The establishment of the Carnegie Foundation for the Advancement of Teaching with its rules for pensions has altered most of these conditions.]

show the trend of thought and practice. They generally apply to the medical department, except that, in case a professor is engaged in the practise of his profession and so has a private income, the provision for continuing a portion of his salary does not apply. This is right and fair. Of course, in all hospitals in which there are no salaries, no provision as to reduced salary would obtain.

The point I wish to emphasize is, however, that the age limit (which in my opinion should be 65) should be *compulsory* and so not be invidious in any given case. It will be objected that not a few men are in full intellectual and physical vigor at 65, and it will be a detriment to the institution to lose their services when their ripe experience and admirable teaching are most desirable. I admit it. But for every one such case of harm done by compelling a competent man to stop, there are a score of instances of men who are doing vast injury by their inefficiency. Moreover, in the very few cases in which it might be allowable, as boards of trustees make rules they can unmake them, and in special cases they could pay a graceful compliment and preserve to the institution their exceptional men by extending the limit to 70. In no case should I think it wise to go beyond this limit.

In some of the universities I have quoted a sabbatical year of rest or study is allowed a professor. He is put upon half-pay, and his place is filled by a temporary substitute, who receives the other half of his salary. I believe that in present conditions this should not be applied to medical faculties, for nearly all of the professors are in active practise and take sufficiently long summer holidays. These latter are often spent in observation and study abroad—a most useful and remunerative employment of a holiday—and serve the purpose of the sabbatical year for men whose entire time is given to their teaching. In hospitals it certainly should not apply.

One of the recurring questions in hospital and college management is whether there should be a certain number of doctors on the board of trustees. I know that there is a wide diversity of opinion upon this point. My own belief is that a small proportion of well-chosen medical men is a distinct advantage on such boards. I have said a "small proportion," for it should not be, I think, larger than probably 20 per cent.; and I also said "well chosen"; that is, they should be men of large mental caliber and executive ability. It should be distinctly understood, if not indeed absolutely expressed, in institutions in large

cities at least, that any physician or surgeon placed upon such a board should never be eligible, even by resignation from the board, for a position on the faculty or the medical staff. In small towns the lack of suitable persons for hospital trustees and members of the hospital staff might make it desirable not to institute such a rule.

Moreover, such medical men should be selected for trustees as by their mental training, social relations and personal character would be, so far as it is possible for human nature to realize such a position, absolutely free from influences arising from personal jealousy or professional bias. If it were a social club, it would be perfectly proper to vote against a man because he is personally distasteful, but where it is a scientific body responsible for the education of large numbers of young men and for the care of still larger numbers of hospital patients among the poor, even if a candidate were personally unfriendly I should vote for his election if he were the man best fitted for the place.

Turning now to the duties and responsibilities peculiar to trustees of hospitals, let me point out the objects of a hospital: First, the care and cure of the sick and injured; secondly, the education of medical men and medical students; and, thirdly, the promotion of knowledge, which, in turn, will inure all over the world to the more speedy and certain cure of the sick and injured, and so be of the greatest benefit to humanity.

In order to accomplish these three purposes, it is necessary that the hospital shall have sufficient funds to purchase ground, erect buildings and provide a thorough material equipment. It is a great pleasure to me, as to you also, to note that throughout the length and breadth of the land the medical and surgical staff never tax the always inadequate resources of hospitals for any remuneration. They serve without pay, they give their time and skill ungrudgingly and freely, day and night, to the poor, often for many years, without ever a thought of any money reward. Their reward comes from increased knowledge and skill, and the daily blessing invoked of heaven, often lisped in children's prayers or breathed in mothers' benisons which pass not unheeded by the Recording Angel.

But, as I have pointed out elsewhere, instead of receiving any pay, they give to hospitals. The mere money value of this daily gift of the profession to the poor amounts to an enormous sum. The value of the professional services of the staff of the Jefferson Medical College

Hospital, a single hospital in a single city, on a moderate basis of fees, I found was more than half a million dollars annually. The millions upon millions of money given in that most self-sacrificing form—personal service—by the entire profession all over the United States, and I might add with still further pride, all over the world, is simply incalculable. The Gideon Grays and Weellum MacLures are not found only in Scotland or at the countryside. They are even more plentiful in the slums of our great cities, giving of their time, their skill, and—what is more—their hearts, their lives, themselves, to the service of humanity.

Trustees sometimes seem to take it for granted that their duties are ended when they have done two things: begged or given and safely invested the necessary funds, and then elected the staff. To my mind, their duties do not by any means end at this point. They should see to it that the resources of the hospital are utilized to the utmost in doing the largest good.

Let us see now how the objects of a hospital, as I have stated them, can be realized. The first object is the care and cure of the patients. But the cure of any individual patient is not the "be all and the end all" of a hospital. His cure must be a means of larger vision to the doctor, who will thus be better fitted to care for future similar cases. Even the death of the patient, if he can not be cured, should minister to the increasing knowledge and skill of the doctor so that he may be able to snatch future victory from present defeat.

The second—the training of doctors and students—is frequently carried out, but sometimes even objected to. There are three classes of doctors who are trained by a hospital: First, the staff of the hospital itself. I have lived through the period of the establishment of hospitals in many of the smaller cities and towns, and in some cases even villages in this country, for it was a rare thing in my early professional life for any except the larger cities to have hospitals. The moment that a hospital is established with its medical and surgical staff, that moment a new era has dawned on the *community* in which the hospital is established. More careful methods are introduced, greater cleanliness is observed, hygienic conditions are bettered, laboratory methods are inevitably introduced in time. Even if the old-timers, who graduated years before our modern laboratory methods were adopted, do not care for them or can not use them, the young fellows who come fresh from

our medical schools and serve as residents, and even the nurses graduated from our training schools, finally shame the older ones into better ways and greater exactness, not only in the hospital, but in their private work as well.

As a consequence of the establishment of these hospitals and of the added skill and training of the local physicians and surgeons, the character of the consultations of the physicians and surgeons of our great medical centers has been greatly modified. The really simple cases, such as hydrocele and small tumors (and even some large ones), club-foot, harelip, etc., which used to be sent to city consultants, are now successfully operated on by the local surgeons, and only the more difficult, serious or complicated cases are sent to the cities. This is a great advantage to the patient, whose good is the first consideration, and to the local medical men; and, though seemingly a serious loss to the city consultant, it is in the end an advantage, as he must prove his better mettle in the higher scientific fields and be, as well as seem to be, a better man.[6]

Moreover, the trustees of every hospital should see to it that a good library and laboratory are provided. Insensibly the staff will read more and more. A single restless progressive spirit, even though it be a young interne, calling attention to this case and to that, in one journal or another, will compel the rest of the staff to read in spite of themselves. It is absolutely clear that a laboratory with modern equipment for bacteriological, pathological and chemical research in its examination of tumors, the urine, the sputum, the feces, the blood, the pus, and other fluids from wounds, etc., is a necessity in every hospital. Even many of our smaller hospitals are equipped with microscope and reagents, if not with a complete bacteriological outfit, which nowadays is inexpensive and imperative. All of this raises the intellectual and professional standard of the staff. I venture to say that no town of 20,000 people can afford to be without its hospital for the sake of its *own citizens,* utterly irrespective of the good it does to the poor who are treated in its wards. It must be established in the interest of the *well-to-do citizens* and their families, so that they may secure better equipped doctors for themselves as well as for the patients in their

[6] [On the other hand, I must utter a warning. The doctor who does a surgical operation only *occasionally* has no moral or surgical right to attempt serious operations which often put to the test all the resources of a veteran operator.]

hospital. Self-interest, therefore, should compel every community to establish its hospital, even if charitable motives had no influence.

Again, the trustees of all hospitals of any size should establish a training-school for nurses. Only those who, like myself, have lived in the period before such training schools were established can appreciate the vast improvement effected in a hospital by this change. To replace the former ignorant, untrained attendants by "trained nurses whose jaunty caps and pretty uniforms and often winsome faces almost make one half wish to be sick, and when one is sick, half loth to be well," is not only a boon to the patients, but to the doctors as well. The intelligent, well-trained nurse, who is on the alert to observe every important change of symptoms and who will keep accurate bedside notes, is the doctor's right hand. Not a few patients who would otherwise lose heart and hope are, one may say, lured back to health and happiness by the tactful attentions and restful, but efficient care of such a nurse. The community of the well-to-do also are benefited, because the hospital provides them with skilled nurses in their homes when they are so unfortunate as to be compelled to remain there instead of going to the hospital.

The old repugnance to entering a hospital when sick or when an operation is demanded is rapidly fading away. The immense advantages of a good hospital over the most luxurious home are now acknowledged on all hands. The poorest patient in a hospital is better cared for, his case more carefully investigated by bacteriological, chemical and clinical methods in a hospital, than are the well-to-do in their own homes. Indeed, wise surgeons, except in cases of emergency, now very properly refuse to do operations in homes instead of in hospitals. In many instances lives that would be lost in homes are saved in hospitals, where the many and complex modern appliances for every surgical emergency are provided.

The hospitals in direct or indirect connection with medical schools, however, do a far larger work than merely the training of their own staffs of doctors. They train three other classes of doctors: First, the undergraduates who are aspiring to the degree; secondly, graduate physicians who spend a certain amount of time in the hospitals either as internes or as temporary students refurbishing their professional knowledge; and thirdly, experts in certain branches of medicine and surgery.

The undergraduates are taught first in the general clinics, where

to some extent they learn both by didactic instruction and by seeing the patients, hearing their histories, and witnessing the institution of proper treatment by prescription, by regimen, or, if necessary, by surgical operation. This is of great value, particularly in the more important cases, and especially, for I speak now as a surgeon, in important operations. It is often objected that students see nothing in large clinics. To some extent this holds good; but no student can look on at an operation when the jugular vein or the lateral sinus is torn, the pleural cavity opened, the bowel lacerated, or other of the great emergencies of surgery occur, and fail to be impressed by the coolness of the operator, the carefully explained methods adopted for remedying the mischief, and the various devices used to save life, all of which hereafter will be used by himself when similar emergencies may occur.

Yet far more important than the public clinics are the smaller clinics held with classes of ten to twenty men each, when under an experienced teacher the absolute work of the clinic is divided among the various students in turn, watching the pulse and the respiration, giving an anesthetic, assisting actively at operations, percussing the chest, palpating the abdomen, determining inequalities of the surface or the varying density of underlying organs. Here is the real forum in which our modern medical student acquires his skill. In many cases visits in the ward itself are made, and to a small group around the bedside the physician or surgeon will point out the phenomena to be recorded, the need for the examination of the blood, the results of bacteriological cultures, the facts discovered by the microscope, or the chemical reagent. By the Socratic method, also, he will reveal to the student the imperfection of his knowledge, call out—e-ducate—his powers of observation, of reasoning; stimulate his thought, and give him an impetus which will last throughout life. Who that has "walked the hospitals" with a Skoda, a Trousseau, a Nélaton, a Da Costa, or a Mitchell can ever forget their teaching?

It is sometimes objected by those who are not familiar with the actual facts, and especially by trustees, that this method of actual bedside instruction does harm to the sick. I speak after an experience of nearly forty years as a surgeon to a half dozen hospitals and can confidently say that I have never known a *single patient* injured or his chances of recovery lessened by such teaching. Of course, the surgeon or physician uses common sense. He would not allow a number of

men to palpate the abdomen of a patient with peritonitis, or move an acutely inflamed joint, nor would the physician allow a patient with pneumonia to have the chest unduly exposed, or a typhoid fever patient disturbed if his condition were such that it would be inadvisable. But such cases are the exception. In fact, many of you are familiar with patients who have responded to repeated percussion by members of such a class by prompt recovery, attributed by the patient to the supposed medication of percussion. Moreover, it is by this actual practise only that the student acquires the necessary skill in the use of modern instruments of precision, such as the stethoscope, the laryngoscope, the esthesiometer, the sphygmomanometer, the various specula. Here he learns when to make blood-counts, how to take histories, arrive at the actual facts by skillful cross-questioning, note the varying symptoms and physical signs of a case, determine the need for laboratory investigations, all under the guidance of skilled observers, who will point out his errors, encourage his queries, and stimulate his thought.

Moreover, trustees may overlook one important advantage of a teaching hospital. Who will be least slovenly and careless in his duties: he who prescribes in the solitude of the sick chamber, and operates with two or three assistants only, or he whose every movement is eagerly watched by hundreds of eyes, alert to detect every false step, the omission of an important clinical laboratory investigation, the neglect of the careful examination of the back as well as the front of the chest, the failure to detect any important physical sign or symptom? Who will be most certain to keep up with the progress of medical science: he who works alone with no one to discover his ignorance, or he who is surrounded by a lot of bright young fellows who have read the last *Lancet* or the newest *Annals of Surgery* and can trip him up if he is not abreast of the times? I always feel at the Jefferson Hospital as if I were on the run with a pack of lively dogs at my heels. I can not afford to have the youngsters familiar with operations, means of investigation, or newer methods of treatment of which I am ignorant. I must perforce study, read, catalogue, and remember, or give place to others who will. Students are the best whip and spur I know.

Of the value of training graduates in post-graduate work I need scarcely speak,—to this audience at least. The doctor who graduated five, ten, or fifteen years ago comes to our great centers of medical education and renews his youth at the fountain of knowledge. He

learns the use of all the new instruments, see new methods of operation, new methods of treatment, new means of diagnosis, and goes home an enormously better equipped man.

The trustees should see that the staff does not become fossilized by following the same ancient local methods from year to year, but should encourage them to visit other hospitals, see other men operate, hear other men discourse on the latest methods of investigation, and then import into their own hospitals all the good found elsewhere. I learn a deal by such frequent visits to the clinics of my brother-surgeons, and if one who has grown gray in the service can thus learn, surely the younger men can do so. When we are too old to learn, we are too old to remain on a hospital staff.

I do not know anything which has more impressed upon me the enormously rapid progress which surgery is making than a recent experience. I was absent from this country for almost a year and a half. In that time circumstances were such that I saw almost no medical journals and but few doctors. I have been home now eight months and even with incessant work I have not yet caught up, so rapid has been the progress of surgery in this short time. Had I been absent for five years, verily I should have been a "back number," and never could have caught up at all.

In his very excellent presidential address before the Association of American Physicians in 1901, Professor Welch made a plea for hospitals to afford "the requisite opportunities to young men who aim at the higher careers in clinical medicine and surgery." He called attention to the fact that in our bacteriological, pathological and anatomical laboratories the opportunities, though still too few, were reasonably good, and in a few places exceptionally good, for the training of young men for positions as teachers of anatomy, pathology and bacteriology. Any young man in these departments who by good hard work makes for himself a name is fairly sure, before long, of being called to some important post as a professor, director of a laboratory, or some similar position. But the facilities for work in clinical medicine and clinical surgery are far more restricted, since opportunities for both the exercise of their clinical skill are less frequently open to them and the possibility of combined physiological, pathological, bacteriological and anatomical research along with their clinical work are but scantily provided for. This plea is reinforced by a recent paper of Sir Michael Foster.[1] These

[1] *Nineteenth Century*, January, 1901, p. 57.

special graduates, bright young men, determined to devote themselves to one or another department of medicine or surgery, are the men who bring honor to the school at which they obtain their training, and are invaluable to the community. They are future Jenners, Pasteurs, Virchows, Listers, Da Costas and Grosses, and our hospitals should provide exceptional facilities for these exceptional men.

The third object of a hospital is the promotion of knowledge, and so, fourthly, the good of humanity. Physicians and surgeons engaged only in private practice do not generally keep notes of their cases, and rarely publish important contributions to knowledge. I find in 100 books taken consecutively in my library that 85 were written by hospital men and only 15 by authors not connected with any hospital so far as was indicated on the title page.

In order that proper investigations may go on, trustees should enforce a permanent record of all the cases treated in the hospital, properly indexed, from which the staff may derive their data for papers and books. Each large hospital should have its pathological resident as well as the clinical residents in the various wards, so that post-mortem records shall be well kept, pathological, bacteriological and chemical investigations of various secretions or blood-counts, etc., shall be properly made and permanently recorded in such a manner—best by a modern card-catalogue—as to be accessible.

It is too often the case that trustees, as I have said, regard their duties and responsibilities at an end when they have taken care of the funds and elected the staff. They may say that, after all, this is their real duty, and that all I have advocated is medical and surgical, and that the responsibility for it should devolve on the staff, and not on the trustees. I do not take so narrow a view of the duties of trustees. When they have elected a physician or surgeon, if he neglects his duty, it is their business to displace him and fill his place with another man who will attend to his duty, and the duties that I have indicated pertaining to the increase of knowledge as well as of its diffusion are quite as much within their province as it is to see that the funds are invested and re-invested to the best advantage. The intellectual funds as well as the invested funds must bring in good dividends.

If trustees and staff work together for such a purpose and in such a manner, they will create an ideal hospital which will do more good to the patients than any other type of hospital. It will attract the best

physicians and surgeons in every community, will acquire the best reputation, not only local, but it well may be national, and do the most for the good of science and the benefit of humanity.

It may be said that this is an unduly strenuous view of the duties of trustees, that in our father's day and in our own earlier lives no such conditions existed or were contemplated. Said President Roosevelt in addressing the Methodists assembled in council:

> I need hardly ask a body like this to remember that the greatness of the fathers becomes to the children a shameful thing if they use it only as an excuse for inaction instead of as a spur to effort for noble aims. . . . The instruments with which, and the surroundings in which we work have changed immeasurably from what they were in the days when the rough backwood preachers ministered to the moral and spiritual needs of the rough backwoods congregations. But, if we are to succeed, the spirit in which we do our work must be the same as the spirit in which they did theirs.

Moreover, we must remember that

> the world field into which all nations are coming in free competition by the historical movement to which all narrower policies must sooner or later yield, will be commanded by those races which, in addition to native energy and sagacity, bring the resources of scientific investigation and of thorough education.

The international race for the leadership of the world is just as strenuous and intense in medicine as it is in commerce. If we are going to join the race and win the prize, there must be the highest development of American education at the top. The best men must be pushed to the front, and ample opportunities for growth, for investigation, and for original research must be provided. Never has there been so large an opportunity for the man of large ideas, complete education, and indomitable energy and purpose as there is to-day. The world is waiting, looking, longing for him and will cry "Make room" for him when he is found.

In the hands of the trustees of our colleges and hospitals are the money and the opportunity for developing such men. If the right spirit pervades both trustees and medical faculties and hospital staffs, then it will be but a short time before America will lead the world in medicine as well as she now does in commerce.

Will the profession rise to the level of their great opportunity? Yea, verily they will! Never yet have they been wanting when the emergency arose; not only the emergency of labor, but also the emergency of danger.

In Russia the common soldier counts for little. Yet in Vladikavkaz (where the Dariel Pass—the old Porta Caspiæ of Herodotus—leading from the Caucasus joins the railroad from Baku on the Caspian to Moscow) is a monument to a common soldier. At the last battle in which the Russians won the victory over Schamyl which gave them undisputed sway over the Caucasus, this soldier blew up a mine and won the day at the cost of his own life. It was ordered that his name should never be erased from the list of his company. At every roll-call when his name is reached, the solemn answer is given, "Died in the service of his country."

In our hospitals lurk the deadly breath of diphtheria, the fatal virus of bubonic plague, of cholera, of yellow fever, of typhoid fever, and the ever-present danger of blood-poisoning. I have known of brother-physicians who have died victims to each one of these scourges. Yet who has ever known one of our guild to shrink when danger smote him on the right hand and the left and death barred the way? As brave as the Russian soldier, ready to risk life, and, if need be, to lose it, these martyrs to duty shall never have their names stricken off the honor list, and at the last roll-call the solemn reply shall be, "Died in the service of humanity."

RESEARCH FOUNDATIONS IN THEIR RELATION TO MEDICINE[1]

By Henry H. Donaldson, Ph.D., Sc.D.,
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At this time and place, medicine is the central interest, and therefore, so far as a layman can, it is my purpose to discuss "Research Foundations in their Relation to Medicine," and if possible to do this in such a manner as to reveal their significance to those for whose encouragement these ceremonies have been devised.

To accomplish this I intend first to ask you to consider the mental attitude necessary for the appreciation of research foundations and then to describe these foundations broadly—trying to indicate their relations to the universities; the problems which arise in connection with them; the dangers to which they are exposed; and their significance for the progress of medicine, for yourselves and for the development of the spirit of research.

You who are about to pass from the discipline of the school to a more self-dependent phase of your career feel both the fresh pleasure of restraints outgrown and a questing interest in the coming years. You feel too that, broadly speaking, what will happen to medicine during the next fifty years will also happen to you, and that at any moment some of you may be called upon to guide these happenings.

In the face of such responsibilities it becomes a duty as well as a wise precaution, to obtain the broadest possible view across your chosen field and to gain knowledge of the larger changes and improvements taking place within it.

You may have done this several times before, but I venture to predict that if you live and succeed, you will do it many times again.

The Greek philosopher Heraclitus laid weight on the idea that all things are in a state of flux. The notion has not always been approved. We know that this idea in some of its aspects was repugnant to the early Victorian gentlemen, but to-day we are less prone than those of

[1] Address at the graduation exercises of the Yale Medical School, June 17, 1912. Published in *Science*, July 19, 1912.

earlier generations to dogmatize on the impossible, and in this country and this phase of civilization we feel with its full force the forward flow of things, so that for us nothing is more certain than the progressive change and onward movement in medical theory and hence in medical practise.

During the years of your training you have been carried more or less unconsciously along and thus helped to keep in touch with the development of medical thought, but at this moment, when the stream of knowledge is about to cast you out upon its shores and you are asked to walk on alone, it is worth while to inquire what is your preparation for the experience.

From these halls and laboratories you bear away a load of learning—haply you bear it lightly. It is to this possession that I wish to direct attention for a moment.

The knowledge we accumulate is a very mixed article, but in this mixture there are two sorts which it is well for us to consider now. One sort consists of certain formulas which control our incidental actions; for instance, we all know on occasion when to stand up or to sit down, and you know the technique and procedure for various surgical operations. A great fraction of our information is in this form, a form not necessarily subject to frequent or radical change. This sort, however, is of minor interest to us now, and has been mentioned here only that it may serve as a foil to the more important kind.

This more important kind of knowledge is that on the basis of which we can foresee and predict.

There are manifold varieties of this and they range from that which permits us to predict with a high degree of confidence the rising of tomorrow's sun, to that with which one ventures to predict the weather or the fate of a patient with baffling symptoms.

In these latter instances the cause of events is by no means unpredictable, but only so dependent on complex factors and conditions that we rarely have at once at hand enough information to make a respectable guess. This fact bears very directly on the matter before us, for when we scrutinize our intellectual possessions we find them to consist in large measure of information useful for prediction, yet mainly information so incomplete that the conclusions or theories—if you choose—based on it must be largely held as open to revision and therefore can be used with safety only by those who carry in mind just how much

or how little each conclusion has to rest upon. Nevertheless, it is just these tentative conclusions or theories which the medical man must so largely utilize. Probably you have thought of this before; if so, you know that to the revelations of this analysis men react in very different ways. Some throw up their hands in the face of so much uncertainty; others stretch certainty to the limit and seek to make it cover all they have been taught and then cultivate impenetrability because change is disquieting and new knowledge means new labor, while those born under happier stars are neither crushed nor blinded, but recognize that intellectual health and vigor imply an unceasing replacement of both data and conclusions, to be accomplished only when the period of mental growth is made conterminous with life.

Capacity for such continued growth is conspicuous in the masters and a hall mark of the eminent. Indeed, as you proceed in the investigation of your fellows, you will be surprised to find how early growth may cease and how significant the event can be. In far-distant communities mental growth has been known to stop on commencement day. It is consoling, however, to be assured—as I can assure you—that we observe this woeful arrest more clearly and sooner in our fellows than in ourselves—a suggestive fact which needs only to be mentioned in order to be appreciated.

As you see, the reason for this preface touching the nature of our mental possessions is my wish to emphasize the need for the full recognition of the unsolved or partly solved problems in medicine and the necessity for holding in mind the facts on which all such tentative solutions as we use are based. When this need has been recognized, it is possible to take the point of view from which research foundations can be discussed with greatest benefit, for primarily it is their purpose to replace less certain by more certain facts. Indeed, discussion of these foundations can be significant only for those who, like yourselves, know that the students' career is for life, never to be commuted—not even for good behavior—and in no wise limited by any formal function, such as graduation or a state board test.

Turning now to the research foundations themselves, it may be well, by way of introduction, to give a word of explanation touching the coming treatment of them. I desire to speak as an inquirer, not as an advocate, but as these inquiries have led me to some definite conclusions, I shall venture to express them briefly. Beyond this, all things rest with you.

While we are specially interested in research foundations in their relation to medicine, yet those with such relations are but a fraction of the number in existence and for the most part have come late.

A research foundation may be defined as one especially intended to produce new and better knowledge. Thus the main purpose and aim serves broadly to differentiate such a foundation from the universities and other educational establishments in which a greater emphasis is put on the conservation, distribution or application of knowledge, while at the same time both sorts of institutions have been and are producers also. The new foundations are then by no means essentially novel, but in one sense outgrowths or specialized extensions of the older educational establishments. This implies, of course, that what they are devised to do has already been included in the existing scheme of things.

Such being the case, our discussion must be framed so as to comprise these facts.

In the civilization from which we are descended there has always been some endeavor to add to the sum of human knowledge.

The acute minds belonging to the end of the medieval period often overstepped the theological and philosophical bounds within which they had their greatest activity, and gave to the study of the physical world more or less attention. Speculating, compiling, teaching and even experimenting, these men grouped here and there formed the centers from which the earliest universities of our era sprang.

Later appeared the learned academies, also sometimes the patrons of investigation. As objects of study, the physical problems came first, aided by the fact that observational and experimental work could be there begun without the preliminary labors of collection and classification which have necessarily occupied so much time in the biological sciences.

What is important to point out here is this: That whether we date the founding of the modern university laboratory from Lomonossoff at St. Petersburg in 1748, or from Liebig at Giessen in 1826, we must admit that a good deal of investigation had gone on in all the principal departments of science previous to such foundations, and thus in earlier times investigations were made in scientific workshops unconnected with teaching institutions. This fact suggests that perhaps our research foundations have even less novelty than we were at first inclined to accord to them, and that we are dealing now rather with a reappear-

ance of conditions—much improved, to be sure—but quite familiar before the rise of our modern universities. It has a direct bearing on this point to note that in England, for example, during the earlier part of the last century when the historic universities of that country gave only meager support to experimental science and especially to the biological investigations, much of the most important work was done outside of the teaching institutions.

Joule, the student of the mechanical equivalent of heat; Perkin, discoverer of the aniline dyes; Bentham and the Hookers, all three botanists; Galton, the anthropologist, and Darwin, are some instances.

Moreover, for more than a century the Royal Institution of Great Britain, the foundation of which in 1799 was largely instigated by our fellow countryman, Count Rumford, furnished opportunities for research to Davy, Faraday, Tyndall and Dewar, all men whose contributions to knowledge have been of great importance.

According to its charter, the Royal Institution was "an establishment in London for diffusing the knowledge of useful mechanical improvements" and "to teach the application of science to the useful purposes of life."

This does not sound like the program of a research institution today. I can not say just what the steps were which led in this case to a development seemingly so different from that proposed, but it is not rash to assume that the men like those who have been named were always hunting reasons and explanations, knowing quite well that others could carry out the application, while it was theirs to make the fundamental discoveries; an excellent example of the well-known fact that where an institution and a strong man are left to work out the problem of adaptation, it is the institution that gets adapted.

Returning from this diversion to our history, and taking the period from the middle of the preceding century to the present day, one can not fail to recall in this country such an example as the Smithsonian Institution at Washington, and I would add our agricultural experiment stations which started right, then faltered, but are now coming into their own.

More extensive in scope and with far greater resources than any of these is the Carnegie Institution of Washington, whose magnificent undertakings in the field of science are well known, representing as they do a long series of research stations.

The ideas behind these several foundations are of the greatest interest. In his program of organization, in 1847 Joseph Henry, first secretary of the Smithsonian Institution, states the following:

> To increase knowledge: it is proposed (1) to stimulate men of talent to make original researches by offering suitable rewards for memoirs containing new truths and (2) to appropriate annually a portion of the income for particular researches under the direction of suitable persons.

This is what one might expect from Joseph Henry. .

Touching the agricultural experiment stations, the history is complicated and perplexing, but we are justified, I believe, in carrying back the guiding idea in their development to that expressed by Washington in his annual message to Congress in 1796, where he says, when pleading for the establishment of a national board of agriculture, that one of the functions of such a board should be "to encourage and assist a spirit of discovery and improvement . . . by stimulating to enterprise and experiment." This is certainly sound doctrine.

The Carnegie Institution in the original formulation of its general plans was much influenced by the experience and early program of the Smithsonian Institution, but the original statement of aims strikes a new note when it declares one of these aims to be

> To discover the exceptional man in every department of study whenever and wherever found, inside or outside of schools, and enable him by financial aid to make the work for which he seems specially designed, his life work.

It is said that this paragraph touching the exceptional man has caused much trouble to the Carnegie Institution and often spread its path with thorns. It appears that in some instances it has been misunderstood. Self-discovered exceptional men have proved to be embarrassingly numerous. That does not strike one as so very strange, however, since the community grows wise but slowly.

The word "exceptional" you see has suffered misinterpretation. The really exceptional man is not so often the aberrant prodigy as the individual who presents in his composition a large collection of first-rate qualities, no one of which is necessarily alarming, but all of which together make for scientific effectiveness of the highest order. In the course of its development, the Carnegie Institution has, I think, lived up to this ideal with notable success—putting the saner interpretation on the word "exceptional." My commendation of the paragraph is similarly based.

But none of these instances which I have mentioned—together with

a large group of others—come very close to medicine. This contact was first clearly established in 1888 by the Pasteur Institute in Paris, an institute intended to facilitate the work of the great scientist whose name it bore, and to continue the remembrance of him. It was an instance of the generous giving of aid and assistance to a master-man—with no prescriptions and no hampering limitations. Pasteur was a genius who combined the art of mediation between the laboratory facts and practical problems, with the capacity for speculative thought and scientific achievement in the highest sense, and who, nevertheless, did not allow his human interest to impair his scientific thoroughness.

In this country among the foundations closely related to medicine we have recently seen established the Rockefeller Institute, the Memorial Institute for Infectious Diseases, the Ortho S. A. Sprague Memorial Institute, both of these at Chicago, together with a number of others representing much the same purpose, but with less ample resources, as well as several funds devoted to the study of cancer, tuberculosis or other special diseases. These instances, because they touch medicine, might well be examined in detail, but we shall discuss them only in their most general relations.

It seems a fair question to ask why these institutes and funds have been established. The immediate causes are plain enough, and are frankly philanthropic in most cases. Personal experience with a disease has led more than one man to devote a large sum to the search for its control or cure, or, going a step further and recognizing that the application of laboratory results to medicine has brought progress, some have desired to furnish opportunities by which this application may be accomplished where it seemed most needed. Though not always explicitly expressed, the programs of these foundations imply the hope that by such endowments new facts and new points of view fundamentally important to medicine may be discovered.

I like to think that this last idea is at least latent in all these endeavors, but nowhere, so far as I know, is quite the same note struck as that which is sounded in the initial program of the Carnegie Institution in those words which call attention to the exceptional man—the investigator.

Turning now to some of the relations involved, it is to be observed that these new foundations are independent and not connected with existing universities, that they tend to draw men from university posi-

tions by the attraction of unusual opportunities for work, and finally, that for the most part they take these men away from formal teaching.

The situation thus created in the world of education has often been lamented and no little moral pressure is exerted from time to time to induce the institutes to see the wrongness of their position.

The question thus raised amounts to this: Are these new foundations philanthropic vagaries and mere torsos of educational establishments, or do they represent the result of mature consideration and a definite endeavor to advance?

Of the several reasons which have brought about the independence of these foundations the common desire to keep alive the donor's name and fame has played its part, but more than this I think has been the feeling that since these foundations were to be devoted to research, either in the line of mediation to which I have already referred, or in the endeavor to obtain new truths of fundamental importance, therefore the workers in these institutes should be as far as possible released from any duties likely to divert their energies. To make this arrangement within the limits of a university is, to say the least, to subject the favored appointee to no little strain.

His colleagues, being human, at heart often resent his seeming freedom from responsibility and he is allowed to feel that somehow he does not justify himself by attending to his work alone. It is unnecessary to enlarge on this situation, but I can assure you that it is no mere product of my fancy. Separateness of management brings protection therefore to those who choose this work.

Still more important for ultimate success is the general conduct of such a foundation. Our universities are guided by experienced administrators who feel keenly the need for the diffusion of knowledge, for making it accessible to large numbers and for preserving withal a completeness and balance in their institutions.

These views become ingrained, but they do not represent the aims of a research foundation and the same board could hardly manage both with like success. For the investigator, buildings are fine when they suit his purpose; after that he loses interest. His notion of efficiency is a large emergency fund, and whether the fixed charges are great or small is not so important as the means to act promptly, decisively and even expensively when occasions arise. This arrangement is possible only when the institution is a good deal of a unit and absolutely free.

To appreciate the needs thus briefly outlined requires the experience which breeds sympathy, and it has thus come to pass that so far as the arrangement of the scientific program, the formation of the personnel and the expenditure of funds are concerned, the control in many of our institutes is in the hands of the staff, aided by a small group of scientific advisers, themselves active workers and keenly alive to the needs of the investigator. This leaves the actual care of the funds with the trustees, but puts the scientific activities in the hands of scientific men. The arrangement solves several problems and seems essential for the healthy development of research foundations.

In view of all of these facts it does not appear very strange that independence has been desired for the newer establishments.

This brings us to the problem of getting men—men who will attempt to realize the highest aims and aspirations of these foundations. These have been taken largely from university laboratories and have been attracted to the newer work by the prospect of more time and resources to apply to their chosen problems and by more fitting salaries.

Of course it has happened at times that in arranging the program of some foundations, emphasis has been put on finding the answer to some specific question which was in the donor's mind. This is unfortunate so far as it implies a limitation of the scientific work, but on the other hand, in many cases the investigator has been given ample freedom to pursue his own courses and devote his time to matters often seemingly remote; in other words, to follow where his research led. The situation demands above all things faith in the sincerity of purpose of the investigator, and fortunately this is granted with increasing frequency.

In these institutions which serve to mediate, on the one hand, between the findings of science and practical problems, and on the other to give opportunity for the attainment of fundamental facts, there is a constant danger threatening every searcher after new knowledge. The mediation work, because it involves as one element a practical problem, is moderately intelligible to the laity and extremely handy when it comes to giving an account of things done. It may become thereby unduly attractive.

By contrast, the search for the new knowledge is rarely intelligible to the community at large, and must often be described in terms of things in mind rather than of things accomplished, and thus this kind of activity often lacks for encouragement. Let me illustrate. Some years

ago the need of protection from diphtheria was urgent. The infecting organism and its biological characters, on the one hand, were known; on the other, the dread disease was only too familiar. How could laboratory knowledge be used to solve the clinical problem? You are familiar with the answer which was given in the form of the diphtheria antitoxin. That is a splendid example of work in mediation as done in research institutes.

But a further question arises: How does the antitoxin produce its effect? This is quite another sort of problem; at first glance it appears to have little practical bearing and yet the answer to it in even one instance may lead to a wider view of the process of immunity. The solution of problems of this class is different from the work of mediation, certainly of equal rank with it, and yet in every way harder to support and harder to carry on, since the results can not in the first instance possibly appeal to any save the well-trained few. In this there lies an obstacle to progress which you can largely help to remove.

Because the men who can do this latter kind of work are relatively rare, even among investigators, because such work can have rational appreciation from a limited group only, and because knowledge of this sort is sure to become the basis for many mediations in the future, it behooves us all to see to it that we foster such investigators—the most valuable of our natural resources. Perhaps it occurs to some of you that you have seen one well-known type of the man I here commend. Let me recall him to you.

An elderly gentleman with an unprogressive costume and unsteady gait, who generally fails to recognize his friends upon the street and requires several seconds to accomplish the recall when spoken to. Such is the mildly humorous picture with which all are familiar. It is often correct so far as it goes—only it is a bit incomplete.

One should add that this man is working with his head, a fact which accounts for almost everything and leaves us pondering why this symptom complex so readily excites remark.

Connected with the conduct of research in these foundations are several other problems of more than passing interest. The fear is sometimes voiced that in the absence of students, those at work will lack an important stimulus and suffer deterioration.

The danger varies with the man. Instances are known where men have failed to feel the attraction of institute opportunities, because they feared the loss of this companionship.

On the other hand, we have the attitude represented by the German university professor who is said to have remarked at the opening of the fall semester, "Now comes this disagreeable interruption of my work." Doubtless he was a wicked old dyspeptic, but for a moment he rose beyond himself and spoke for his burden-bearing caste.

Let me beg not to be misunderstood. I would not for a moment be thought to maintain more than the simple thesis that while teaching is a genuine stimulant to some, it is certainly a depressant to others and especially a depressant to those who are disturbed by interruption, so that some can drop it without damage to themselves.

In compensation it may be urged that the effect of the investigator's methods and personality is felt by those with whom he is usually surrounded, his colleagues and assistants, and when so surrounded he is in no more danger of isolation than a man in the university. However, that is not saying very much, for isolation among colleagues even in universities is a condition which we not only lament, but should also seek to change. It is an ancient tale.

The investigators of four centuries ago were chary of talking of their results and these were often published posthumously, as the authors preferred to die without assistance—or the new discoveries were sometimes couched in cryptic writings as though the author felt that what had given him such years of labor to find out should at least be hard for others to attain. That feeling is sometimes found to-day.

Once I remarked to a student, "Your thesis is three times too long." "Yes," he replied, "but if I did not make it long, how would any one know it had taken me two years to do the work." We can replace this by a better thought. The opportunity to satisfy one's longing for research is a noble privilege, but it brings its obligations. The advances thus made should be returned as rapidly as possible to the fund of common knowledge, and made accessible to the community at large.

This is essential for the progress of the plan, for most surely is the advanced worker dependent on his colleagues as they on him, and ultimately too he is in a larger sense also dependent on the community about him; so for both these reasons cooperation of the most complete sort is needful for the common good.

Expression has been given to the fear that the great resources of our research foundations would breed despondency among those who were compelled to work with simpler devices and less ample means, and thus

they would do harm. Despondency and research do not dwell together.

Research is a frame of mind. A man may have little leisure and trifling resources, may never have published, but if he examines his world in a questioning spirit, if he carries with him not only conclusions, but the observations on which they rest, if he refuses to pound square facts into the round holes that he happens to have in hand, he has attained illumination. The spirit of research is nothing mysterious or remote, it is every-day hard sense. Unfortunately, that does not make it common, but it does make it attainable.

It would be a sorry outcome of these new foundations if they should act as hindrances to investigation in the university laboratories.

The fear that they will do this is often based on the false impression that the supply of scientific problems is limited and thus in danger of exhaustion. Let us be rid of that idea. Every advance creates new problems, problems of increasing importance—exhaustion is impossible.

By reason of the permanency of their programs and freedom from certain forms of responsibility, institutes may wisely undertake investigations of a sort hardly possible under university conditions. The field is thus divided, or rather enlarged. Both the university laboratories and the institutes should gain by this arrangement, and what is more, they do.

Before leaving this aspect of our problem, permit me to point out a peculiar advantage enjoyed by investigators who are working under university conditions. When we contrast the institutes with the universities, we find that it is within the walls of the university laboratory that it is most easy to carry on the search for new knowledge undisturbed by the thought of any applications which it may have.

In the face of some things already said, this statement may appear paradoxical—yet it describes a condition. In the judgment of the educated public, the teaching investigator fulfills his public obligations when he gives a stated amount of instruction. After that, there is a general feeling that the man should be allowed to follow his bent, and if this takes the form of research, the community does not feel obliged to enquire too closely concerning the practical value of the work. Thus in a way the university man is protected in his research by his teaching obligations, while the man in the institute, engaged in the same sort of investigation, is, if anything, more open to criticism, and at the same time without the defense which is possessed by his university colleague, and in so far he stands at a disadvantage.

As you see, I have been concerned in this address with medicine as represented by yourselves in relation to the research institutes, and that explains the manner of this presentation.

It has been my purpose to show that in these foundations we have something which represents an advance in our educational devices.

Their independence is an asset. They may be counted on to mediate in a measure between the initial facts of the laboratory and the problems presented by disease, but more important, though harder to maintain, is their function as laboratories where new knowledge is obtained, which in turn must have still wider applications.

All this concerns you who are just entering on your life work. You can receive direct benefits and enjoy new privileges by reason of these greater opportunities, but they also bring to you fresh responsibilities.

So far as any of you look upon these foundations from without it is my hope that some things have been said which will rouse in you a sympathetic appreciation of the kind of work which I have sought to emphasize as the most precious type of endeavor, for further progress will depend largely on the appreciation and support given to this by the best elements in the medical profession.

The material side of our advancing civilization has developed during a thousand years to an astonishing degree, but we must not be misled, as sometimes happens, into confusing material developments with intellectual progress. These foundations of to-day are but aids to active minds that use them. The mind, the man, is the essential thing, and any device which does not improve him and give him the very best opportunity to increase his powers, has but slight claim to our regard. I desire, therefore, to leave with you a strong impression of the paramount importance of our mental attitude in establishing the right relations between research foundations and medicine.

Permit me then in closing to quote a little fable from Luqman, as it seems to emphasize this point. Luqman, the sage, was reputed, I am told, to have been either an Abyssinian slave of King David or the son of Job's maternal aunt. That question is not settled—but his fable has a pleasant oriental flavor. It runs as follows:

In the heat of the day the lion retired to a cave. While resting there a rat ran over him. The lion jumped up in fright, whereat the jackal laughed. Perceiving this, the lion said, "I was not frightened at the rat, but at my own alarm"; thus showing that to the mighty their state of mind is of more moment than death itself.

IMAGINATION AND IDEALISM IN THE MEDICAL SCIENCES[1]

By the late Christian A. Herter, M.D.,
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The presidential invitation in response to which I am about to address you to-day was welcome to me because it offered a rare chance to express some views of medical progress which I think are too seldom presented to the student. I have in mind the influence of imagination and idealism on the growth of medical discovery. Vividly recalling, as I do, the experiences of my own student days, more than a quarter century past, I fancy you as coming to the acquisition of the myriad facts of medicine with little to tell you of the intellectual forces and historical sequences by which those facts have emerged. If this surmise be correct, it follows that you incline to take a static rather than a dynamic view of the nature of scientific medicine, in the sense that you regard medical lore as something much more fixed than is actually the case. In reality, our science is fortunately plastic, constantly subject to revision of its facts, and ever ready to welcome new interpretations of old facts as well as new discoveries, both great and small. This very plasticity it is that makes progress attainable and fascinates our minds. But our text-books and our lectures are necessarily conservative and dispose us strongly to the notion of fixity of facts, making our minds statical in conception. I would like to dispel, in a measure, this retarding conception by telling you something of the ways in which gifted and trained minds have enriched the medical sciences by significant discoveries. And of the qualities underlying such discoveries I would emphasize especially the rôle of imagination and idealism.

The fine humanitarian aim of medicine always has been and always will be one of the features that make men love to practise the art. And the idealism that delights in the relief of human suffering and disability will remain alive so long as the healing art itself. But we must not

[1] An Address Delivered to the College of Physicians and Surgeons, Columbia University, September 23, 1909, at the Opening of the Medical School. Published by the Press of the American Medical Association.

blind ourselves to the fact that this very attitude of eager desire to help our fellows in distress is a source of weakness as well as a pillar of strength. For he who would answer the calls of the sick must resort to direct methods and must generally tread the paths of the obvious. He has not time to turn aside to the indirect ways of winning the citadel, nor, indeed, is he likely to be in that frame of mind which urges to such an approach; he is preoccupied with the crying needs of the suffering or dying man committed to his charge. Yet it is growing every day clearer that the progress of the medical sciences depends in a remarkable degree on discoveries made by indirect methods—that is, by methods not looking to the immediate relief of disease.

These discoveries are made chiefly by men who, while in deep sympathy with the humanitarian aims of medicine, nevertheless find time to turn aside to studies and experiments from which the active practitioners are, in general, excluded, by the circumstances of their lives and the intensely practical nature of their vocation. There was a time when the alert physician or surgeon, with little or no training in the experimental method, might make important contributions to knowledge by following rather evident suggestions derived from the study of patients. The Romans, operating for stone in the bladder; Paré, using the ligature to check hemorrhage on the field of battle; McDowell, successfully removing ovarian tumors, give us examples of great advances along rather obvious lines of development. To-day the chances for significant progress in such evident directions, although not exhausted, are far less frequent. The golden nuggets at or near the surface of things have been for the greater part discovered, it seems safe to say. We must dig deeper to find new ones of equal value, and we must often dig circuitously, with mere hints for guides. Our most effective tools are to be found in the experimental laboratory, where the fundamental sciences, physics and chemistry, come to the aid of physiology, biology, pathology and psychology. I should like to tell you of some of the many instances in which these sciences have come to the succor of medicine and have brought her riches of knowledge unattainable had she been limited to resources belonging to the accumulated experience which makes up the accepted material of medical teaching. If I incidentally say something of the personality of the men who have been the living instruments of this progress, it is in order to give you occasional glimpses into the workings of some of the most original and productive of minds.

I like to think of medicine in our day as an ever-broadening and deepening river, fed by the limpid streams of pure science. The river at its borders has its eddies and currents, expressive of certain doubts and errors that fringe all progress; but it makes continuous advances on the way to the ocean of its destiny. Very gradual has been the progress of its widening and deepening, for it is a product of human ingenuity and artifice, and only skilled engineers could direct the isolated currents of science into the somewhat sluggish stream of medical utility. The names of some of the greatest of these engineers are familiar to you—Vesalius, Harvey, Malpighi, John Hunter, Claude Bernard, Helmholtz, Virchow, Metchnikoff, Pasteur, Lister, Koch, Behring, Ehrlich, Emil Fischer, Weigert, Wright, Theobald Smith, Flexner. Different as have been the achievements of these men, there are some qualities of mind and of heart which nearly all of them have shown in ample measure, and of such qualities none are more evident than imagination, or play of fancy, and personal idealism, using the latter term to mean a readiness to make sacrifices for the sake of lofty achievement. And I think we are quite safe in making the generalization that the discoveries for which we hold these thinkers in honor would have been impossible but for the exercise of these qualities. If this be true, the fact furnishes us with a clue to present tendencies in medicine and shows us to what sorts of gifts we have to look for the significant advances of the future. I, therefore, hope to make good my generalizations by a series of examples.

If we look over any list of the names of the makers of modern medicine, we shall find that they may be classed in two main and definite groups, according to the intellectual trend for which they stand. One group holds the men who look at the problems of medical science largely from the standpoint of structure and arrangement. They have the instincts and interests of the morphologists. They represent anatomy, embryology, pathological anatomy and histology. They have usually been men of powerful and logical minds, craving the positive, the definite and the attainable, either shunning somewhat the speculative aspects of science, or moving uncomfortably in the midst of ill-defined or challengeable facts. In this list belong Vesalius, von Baer, Bichat, Virchow and Weigert, who represent with maximal distinction the group of investigators with dominant morphological tendencies.

In sharp contrast with this definite type stands the second group, made up of men whose interests lie in the study of function, rather

than structure, and whose minds, far from being dismayed by the speculative aspects of their studies, invite such speculation so long as it is severely controlled by frequent appeals to facts won by experiment. The members of this small group are dynamically minded, highly imaginative, delighting in the play of forces. They are essentially experimentalists, and their thoughts in leisure hours, as in the hours of work, turn always restlessly and uncontrollably in the same direction —to the planning of new experiments designed to answer the questions uppermost in consciousness, questions having nearly always to do with the phenomena of living beings. Claude Bernard, Helmholtz, Pasteur and Ehrlich are the unexcelled prototypes of investigators of life-phenomena in medicine, and we shall not go far astray if we fancy them as spirits inspired by

> All that is great and all that is strange
> In the boundless realm of unending change.

We have also, I think, to recognize an intermediate group of great investigators who, while highly trained in a morphological way, have shown also a deep and productive interest in the functional aspects of organized nature, without, however, attaining the highest levels of achievement in thought on the dynamical side of medical research. In this category we may place Harvey, Malpighi, John Hunter, Johannes Müller, Cohnheim and Robert Koch. And I think we may safely add that most modern investigators, educated under the influence of the strong trend to physiological thought, belong in this intermediate position.

The examples of medical discovery which I shall first bring to your notice I shall select from the first and intermediate groups of workers, reserving the illustrations from the second group for subsequent consideration.

The first great morphologist of modern times is Vesalius, whose claims to recognition rest not merely on his masterly and precise description of the parts of the human body, but also on his abrupt departure from the Galenic traditions and teachings, forced on him by the objectivity and sincerity of his studies. While we must regard the work of Vesalius as evidence of intellectual and logical power, it would be an error to credit him with the highest type of imagination or with elaborate esthetic reactions. The self-willed, clear-thinking man won his triumphs more by force of character and unswerving purpose than by

creative intellect; and we see this type of worker repeated in some of our greatest modern anatomists, as also in some fields in which the experimental method is prominent.

The idealism which inspired Vesalius was not proof against exasperations and discouragements due to the hostility of the Catholic church to all research on the human body. After destroying valuable manuscripts and resigning his professorship, the great anatomist attached himself to the court of the Emperor Charles V and afterward to that of Philip II. But power and position and wealth did not repay him for the loss of intellectual freedom which such associations imposed, and for some reason he left Spain to visit the Holy Land. It is said that the pilgrimage was made in penance for an autopsy performed on a young woman not quite dead; and Edith Wharton has seized on the story to enrich her admirable Browning-like poem, "Vesalius in Zante":

> The girl they brought me, pinioned hand and foot
> In catalepsy—say I should have known
> That trance had not yet darkened into death,
> And held my scalpel. Well, suppose I *knew*?
> Sum up the facts—her life against her death.
> Her life? The scum upon the pools of pleasure
> Breeds such by thousands. And her death? Perchance
> The obolus to appease the ferrying Shade,
> And waft her into immortality.
> Think what she purchased with that one heart-flutter
> That whispered its deep secret to my blade!
> Ah, no! The sin I sinned was mine, not theirs.
> Not *that* they sent me forth to wash away—
> None of their tariffed frailties, but a deed
> So far beyond their grasp of good or ill
> That, set to weigh it in the Church's balance,
> Scarce would they know which scale to cast it in.
> But I, I know. I sinned against my will,
> Myself, my soul, the God within the breast;
> Can any penance wash such sacrilege?

How vividly and how justly these verses paint the remorse that came from adandonment of ideals, when the young investigator, not yet thirty years of age, exchanged the inner satisfaction of legitimate work for the prestige of courts!

But Vesalius in that short span of work had founded anatomy, and Eustachius and Fallopius, his successors, united their influence with his (despite some disloyalties and antagonisms) to establish the scientific

method in this branch of learning. The future of anatomy in Europe seemed assured. This gain in scientific method, initiated by Vesalius, was fixed and established in England by the spirited, penetrating and imaginative William Harvey, whose monumental work proved that all the blood in the body travels in a circuit impelled by the beating of the heart. That a highly skilled anatomist should have made this physiological discovery is significant evidence that studies in structure may stimulate a labile mind to serious investigation of the functional side of organic nature. Probably the work which Harvey did with his master, Fabricius, at Padua in the anatomy of the vascular system stimulated his interest in the discovery of experimental methods which should expose the true uses of this elaborate mechanism. And the same ingenuity which led to such conspicuous success in physiological research, the same interest in the vital phenomena, caused Harvey to ponder and study the mysteries of development in the chick, the deer and other mammals. These embryological observations are of such a grade of excellence that some of the greatest biologists regard them as superior in quality to the immortal studies of the circulation.

The lofty intellect of Harvey was linked with a generous and idealistic nature. His portraits show a formation of head and face that reminds us of representations of Shakespeare. Like Hunter and Darwin, he had the virtue of being extremely slow in publishing. He forgave his many antagonists, notwithstanding the troubles they brought into his life. He says:

> I would not charge with wilful falsehood any one who was sincerely anxious for truth, nor lay it to any one's door as a crime that he had fallen into error. I am, myself, the partisan of truth alone; and I can indeed say that I have used all my endeavors, bestowed all my pains on an attempt to produce something that should be agreeable to the good, profitable to the learned, and useful to letters.

More than a hundred years after the death of Harvey there emerged from obscurity a Scotchman, John Hunter, of such power and versatility as to make him a worthy intellectual successor of the great Englishman. We may take him as our second example of an investigator of our intermediate group, combining the interests of morphologist and physiologist. Of his works as anatomist and surgeon and comparative anatomist, I shall say nothing here. The wonderful Hunterian Museum of London is a peerless monument to the labors of the anatomist and surgeon. But it does not especially direct our thoughts to his physio-

logical and experimental way of thinking, which we may safely consider his strongest claim to greatness. One example—a celebrated instance—will illustrate the point I wish to make. It was in Richmond Park that Hunter saw the deer whose growing antlers awakened in his mind a singularly fruitful physiological question. What would happen if he shut off the blood-supply of the antler on one side by tying the corresponding carotid artery? Experiment showed that the antler lost its warmth and ceased to grow; but for a short time only was there this check to growth. After a time the horn warmed again and grew. Had he failed to really obstruct the blood flow in the artery? No. Examination showed the carotid to have been securely ligated. Whence, then, came the blood essential for the antler's growth? Through the neighboring arteries that had grown distended, through what we now call the collateral circulation. So was the fact of the collateral circulation revealed. The thoughtful and logical mind of the practical surgeon soon found an important application of this discovery to human pathology. No one had dared to treat aneurism by ligation for fear of causing gangrene. But the existence of a collateral circulation held out a prospect of keeping the parts alive despite the ligation of an important artery. The first trial of the new method on a popliteal aneurism was successful, and the Hunterian operation, as you know it in surgery today, came into assured existence. An unimaginative man could not have made this discovery in this manner. Yet Hunter belongs to the logical, independent, matter-of-fact type with fancy well controlled, rather than to the dreamers and poets of science. He was a rough diamond, with an intensely objective nature, and he had corresponding limitations. He is said to have rebelled against the classical teachings of Oxford. "Why, they wanted me to study Greek. They wanted to make an old woman of me!" And when twitted with his lack of knowledge of the "dead languages" he said of his critic: "I could teach him that in the dead body which he never knew in any language, living or dead." The idealism of Hunter showed itself in devotion to work and in fortitude in the adversity of ill health.

I wish now to invite your attention to our second type of investigator —the essentially dynamical or physiological discoverer. The group, as I see it, is a small one. It includes Claude Bernard, Louis Pasteur, Hermann von Helmholtz and Paul Ehrlich.

An admirer said sententiously of Bernard: "He is not merely a

physiologist; he is physiology itself"; and the saying has the merit of reminding us of the breadth and depth and originality of his researches. With equal skill he worked at the physical and chemical bases of physiology; and we owe to him our knowledge of the glycogenic function of the liver, the enzymes of the pancreatic juice, the vasomotor system of nerves, diabetes from puncture of the fourth ventricle, besides many minor discoveries and researches and a masterly correlation of the general facts of animal and plant life. Bernard was one of the founders of modern pharmacology. He also foreshadowed in a singular manner and under singular circumstances the modern conception of soluble ferments in microorganisms, a view which unfortunately brought him into an unpleasant antagonism with his lifelong friend, Pasteur.

The research that most fully shows the controlled imagination of Bernard is that which, extending over years, culminated in the discovery of the glycogenic function of the liver, a discovery of the very first significance to physiology and pathology. We know the steps which led him to this discovery, and in retracing these steps we get an edifying glimpse of the workings of Bernard's fertile mind. His ambition was to follow the three great classes of foodstuffs, carbohydrates, fats and proteids, through the organism. He soon felt the necessity of limiting himself to the fate of the carbohydrates, which, besides seeming relatively simple to study, especially attracted him on account of their mysterious relation to diabetes. The first step in the research brought out the fact that cane-sugar, when acted on by gastric juice, undergoes a transformation which adapts it for absorption and utilization by the tissues—namely, a change into dextrose (glucose). He knew from the experiments of Tiedemann that starch is changed into dextrose in the digestive tract before absorption. Bernard asked himself what was the fate of this dextrose. He proposed to trace the course of the sugar from the digestive tract, along the portal vein to the liver, from the liver to the lungs by way of the right heart, and finally from the lungs through the left heart to the various tissues. His idea was that at one of these stations the dextrose disappears, is destroyed or in some manner changed. "If I am able," said he, "to suppress the activity of this station, sugar will accumulate in the blood and a condition of diabetes will be brought about." Here, then, was a highly interesting enterprise. The first thing to do was to feed a dog freely on carbohydrates, kill it at the height of digestion and examine the

blood leaving the liver by the hepatic veins to see if any sugar were lost in the liver. Please note that Bernard was helped in this search for sugar in the blood and tissues by the cupric sulphate test for dextrose, just introduced by his friend, Barreswill—a very material help. Sugar was found in abundance in the blood of the hepatic veins; therefore, the liver was not the looked-for place of disappearance of dextrose. "But how do I know," thought Bernard, "that the sugar which I thus find in the hepatic vein is the same sugar as that which I introduced into the portal blood through the food?" To get an answer, Bernard fed a dog on meat only, knowing by experiment that no dextrose would then be present either in the digestive tract or in the portal blood. Then he examined the blood of the hepatic vein for sugar. Great was his surprise to find it loaded with dextrose. His keen intelligence at once drew the correct inference—that the liver is a sugar-making organ and makes sugar out of something which is not sugar, and, furthermore, that within the liver lies the secret of diabetes. Bernard now made a variety of experiments to test the correctness of his inferences. He soon found that sugar was contained in a simple decoction of the liver and that this sugar was dextrose, capable of fermentation and responding to all the known tests. But Bernard did not stop here. His fancy urged him to seek the substance in the liver from which the sugar is produced—the "glycogenic substance" whose existence was inferred from experiment. And in time he isolated the substance which we know to-day as glycogen.

Here, then, was a great triumph of the experimental method in the hands of an imaginative, critical and highly skilled technical worker. The completeness with which the discovery of the glycogenic function of the liver was worked out makes it a model of physiological research for all time. Moreover, the facts elicited by Bernard in this research possess a very broad bearing. They show that the liver has a function as important as, but far less obvious than, the secretion of bile—the first example of an internal secretion. And they prove that animals as well as plants can build up carbohydrate material—glycogen—by means of their own tissues. Finally Bernard very clearly showed that, while the production of glycogen from sugar is a vital act, in the sense of occurring only under conditions of life, the converse process, namely, the formation of sugar from glycogen, is independent of living tissues and may occur as the result of the action of a ferment in the blood.

As Sir Michael Foster said most aptly:

> It is in the putting forth of the hypothesis that the true man of science shows the creative power which makes him and the poets brothers. His must be a sensitive soul, ready to vibrate to Nature's touches. Before the dull eye of the ordinary mind facts pass one after the other in long procession, but pass without effect, awakening nothing. In the eye of the man of genius, be he poet or man of science, the same facts light up an illumination, in the one of beauty, in the other of truth; each possesses a responsive imagination. Such had Bernard, and the responses which in his youth found expression in verses, in his maturer and trained mind took the form of scientific hypothesis.

That Bernard well understood the value of imagination in research and also its dangers is well shown by his admirable and memorable advice to his pupils:

> Put off your imagination as you take off your overcoat when you enter the laboratory; but put it on again, as you do your overcoat, when you leave the laboratory. Before the experiment and betweenwhiles let your imagination wrap you round; put it right away from yourself during the experiment itself, lest it hinder your observing power.

The dramatic and poetic instincts were strong in Bernard. He composed a vaudeville comedy called "The Rose of the Rhone," and later a metrical tragedy which he altered to a prose drama. But the love of analysis and of original research triumphed over these esthetic tendencies of Bernard's nature, and in the reserved and inhibited personality and somewhat cold intellectuality of his maturer years it was not always easy to detect this underlying esthetic and emotional trait. His married life did not bring him happiness, as his wife sought display and material successes and was unable to understand the purity of purpose from which he never swerved in the long career to which physiology owes so great a debt.

Let us now bring to your attention some features of the mental life of another great physiologist, Hermann von Helmholtz, representing a very different phase of physiology from that developed by Bernard. Bernard, though accomplished as a morphologist and skilled in mechanical physiology, leaned strongly to the chemical side. He was essentially the animal experimentalist. Mathematics played only the most simple rôle in his researches. Helmholtz, on the other hand, approached physiology on its physical side, and, one may remark in passing, with a quality and amplitude of success unequaled before or since. He used the higher mathematics constantly and they proved keen tools in his hands. Although an experimentalist of the very first order, Helmholtz was not an animal experimenter except in a very limited way, the nature of his themes making vivisection for the most part unnecessary.

Even as a child the mind of Helmholtz was unconventional and inquiring, bent on understanding what was going on about him. The boy cut his own path through the mazes of unassimilable educational offerings. His tastes were definite. He obtained notions of geometry from the blocks with which he played, surprised his mother by experimenting on her linen with acids, made telescopes with spectacle lenses, read books on physics and enjoyed greatly his walks in the country. At the university he assimilated ideas with great ease and showed an increasing interest in physics, which he wished to follow as a profession. But his prudent father urged him to study medicine as a surer means of livelihood. And most fortunate it was for medical science that the gifted young man was willing to take up medical studies, for there arose in him a deep interest in the problems of physiology, destined to bear rich fruit. The duties of an army surgeon took only part of his time and the rest he gave to physics. His original researches began at the age of 21 and continued through a long lifetime, covering an extraordinary range of topics in an original and masterly way. Helmholtz contributes to minute anatomy, lays the foundations of physiological optics and acoustics (with all that this means for esthetics, psychology and metaphysics), gives to medicine the specific and golden gift of the ophthalmoscope, enriches physics with an imperishable statement of the doctrine of the conservation of energy and with original studies on vortex motion, on hydrodynamics, on electrodynamics, on dynamics, on meteorological physics. He broadens chemical theory by the influence of his vortex motion hypothesis and, in a somewhat incidental way, brings new theoretical conceptions into the realm of pure mathematics. As students of the psychical forces that have fertilized modern medicine it is interesting for us to note that Helmholtz disclaimed any intention to be practical in his work. If the themes that happened to absorb his attention led to practical and humanly useful results, he was pleased; but he seldom pursued a practical aim simply because of its utility. He chose his themes because they promised to be intellectually satisfying, giving little heed to the nature of the probable outcome. He framed his experiments so that Nature would have to answer "Yes" or "No" to his questions, thus furnishing him with definite results.

The story of the invention of the ophthalmoscope illustrates the mental processes of Helmholtz in working out an idea. He did not set out to devise an instrument for studying the retina and the ocular

refraction, but as he proceeded these important possibilities ripened into definite objects. He says:

> I was endeavoring to explain to my pupils the emission of reflected light from the eye, a discovery made by Brücke, who would have invented the ophthalmoscope had he only asked himself how an optical image is formed by the light returning from the eye. In his research it was not necessary to ask it, but had he asked it, he was just the man to answer it as quickly as I did, and to invent the instrument. I turned the problem over and over to ascertain the simplest way in which to demonstrate the phenomenon to my students. It was also a reminiscence of my days of medical study, that ophthalmologists had great difficulty in dealing with certain cases of eye disease, then known as black cataract. The first model was constructed of pasteboard, eye lenses, and cover-glasses used in the microscopic work. It was at first so difficult to use that I doubt if I should have persevered, unless I had felt that it must succeed; but in eight days I had the great joy of being the first who saw before him a human retina.

The basis for this invention was Helmholtz's knowledge of the anatomy of the eye, his mastery of physiological optics, his experimental ability, and, as stated in his own language, his wish to devise an improved method of demonstrating a somewhat obscure phenomenon to his students. Modesty and generous impulse made Helmholtz say that Brücke could equally well have invented the ophthalmoscope had he only asked himself how an optical image is formed by the light returning from the eye. I doubt if it could be successfully contended that Brücke's actual information about the eye was less than Helmholtz's. Helmholtz himself says that Brücke "was just the man" to make the invention, and by this he must refer to equipment in knowledge. In what, then, did Helmholtz excel Brücke? I would answer, in creative fancy, in imagination. The controlled play of fancy, using the facts of the case for its playground, is what made Helmholtz see the possibilities and see them so clearly as also to make it appear worth while to put energy into the effort to see the retina.

It would be easy to multiply examples of the almost playful way in which Helmholtz utilized the children of his rich fancy to extend the bounds of scientific knowledge. The ease with which he made his intellectual progress is one of the most striking features of his wonderfully creative career. Often on solitary walks in the country he experienced ideas that seemed to clarify refractory problems. From the great wealth of his impressions and associated ideas, arising through the operation of active fancy or imagination, there seems to have been a process of controlled selection and rejection by which the finished products, the great ideas, were built up—a conscious selection not without

analogies to natural selection in the upbuilding of the physical machinery. In the entire list of the masters of medicine I think there has been only one mind that can be regarded as belonging on the same lofty level as that of Helmholtz, in respect to controlled yet expansive powers of imagination combined with the energy of performance and the technical training necessary to apply those powers. The intellect of Pasteur, and his alone, has revealed associative power and logical sequences of thought culminating in discoveries fairly comparable to those of Helmholtz in respect to the depth of their psychical basis. And it is probably no accident that the two greatest minds in medicine have entered it on the streams of pure science, Helmholtz as the biological physicist, Pasteur as the biological chemist.

As a human being Helmholtz takes rank with the noblest of men. Considerateness for others and a willingness to help worthy persons were prominent characteristics. He had a calm self-control which still left him natural and simple in human relations, although this fine dignity served as a check to the approaches of shallow and trivial people. Helmholtz was an idealist of the purest type, and never permitted personal interest to interfere with his best aims as a student of science. His was a poetic nature, apt in versification and in music, yet with an intellect so searching that he was not entirely satisfied by esthetic feeling and phantasy, but sought also to understand them. Modesty was one of his greatest charms, and this quality was attractively seen in the sentiment which he expressed on being awarded the von Graefe medal in recognition of his services to medicine through the invention of the ophthalmoscope:

> Let us suppose that up to the time of Phidias nobody has had a chisel sufficiently hard to work on marble. Up to that time they would only mold clay or carve wood. But a clever smith discovers how a chisel can be tempered. Phidias rejoices over the improved tools, fashions with them his god-like statues and manipulates the marble as no one has ever before done. He is honored and rewarded. But great geniuses are modest just in that in which they most excel others. That very thing is so easy for them that they can hardly understand why others can not do it. But there is always associated with high endowments a correspondingly great sensitiveness for the defects of one's own work. Thus, says Phidias to the smith, "Without your aid I could have done nothing of that; the honor and glory belong to you." But the smith can only answer him, "But I could not have done it even with my chisels, whereas you, without my chisels, could at least have molded your wonderful works in clay; therefore I must decline the honor and glory, if I will remain an honorable man." But now Phidias is taken away, and there remain his friends and pupils—Praxiteles,

Paionios and others. They all use the chisel of the smith. The world is filled with their work and their fame. They determine to honor the memory of the deceased with a garland which he shall receive who has done the most for the art, and in the art, of statuary. The beloved master has often praised the smith as the author of their great success, and they finally decide to award the garland to him. "Well," answers the smith, "I consent; you are many, and among you are clever people. I am but a single man. You assert that I singly have been of service to many of you, and that many places teem with sculptors who have decked the temples with divine statues, which, without the tools that I have given you, would have been very imperfectly fashioned. I must believe you, as I have never chiseled marble, and I accept thankfully what you award to me, but I myself would have given my vote to Praxiteles or Paionios."

If we turn now to Helmholtz's great contemporary, Louis Pasteur, we discern many points of resemblance in the mental endowments and in the careers of these two superlatively eminent masters of medical science. Pasteur, like Helmholtz, was greatly helped in early life by the patient guidance of earnest and capable parents, and, like him, showed a strong interest in poetry and art, the portraits made by Pasteur during his teens showing unmistakable artistic talent. Pasteur's considerable aptitude for mathematics developed later than that of Helmholtz and was of a less original sort, yet served him well, especially in his earlier researches. Both men were endowed with phantasy and associative power of the highest order, but, while Helmholtz seldom departed from the path of strict logical development of his ideas, Pasteur, with his more impetuous nature, sometimes permitted himself to make speculative excursions of a more random kind. Both found their greatest enjoyment in dealing with the development of general ideas, but Pasteur, on realizing his power to help mankind through his discoveries, deliberately turned his rare gifts to the solution of practical problems in medicine, whereas Helmholtz was satisfied to continue to build the foundations for the physiology of the sense organs and for a better psychology and metaphysics. It is very noteworthy that both Helmholtz and Pasteur were deeply influenced in their outlook by certain conceptions of wide applicability. Helmholtz learned from his great master, Johannes Müller, to attach great importance to the principle of the specificity of nerves—that is, the doctrine which teaches that nerves of special sense, as the optic or acoustic nerves, however stimulated, respond with a quite specific reaction, with sensations of light or sensations of sound, respectively. This principle guided Helmholtz not alone in his studies of the physiology of the special senses, but in his philosophical attitude, which brought him into collision with the widely

accepted metaphysics of Kant. On the other hand, Pasteur's scientific and philosophical thought was influenced definitely and profoundly by the conception of molecular asymmetry in nature. His interest in this subject was awakened by the study of the salts of tartaric acid, which culminated in 1848 with the famous discovery that the optically indifferent or racemic tartaric acid crystallizes into equal quantities of the ordinary dextrorotary tartaric acid and of the newly recognized levorotary tartaric acid. It was Pasteur's interest in the problem of molecular asymmetry, and especially certain theoretical notions on which we need not linger here, that induced him to experiment on the action of microorganisms on racemic ammonium tartrate, with the striking result that the living beings converted the optically indifferent solution of salts into a levorotary solution. This showed that the dextrorotary constituent of the indifferent racemic tartrate had been assimilated by the microorganisms, while the levorotary constituent was unaffected. I emphasize these studies of Pasteur's because they were what excited his interest in the then obscure problem of fermentation, which in turn led him to take up those studies of the causation of disease by microorganisms and those researches on immunity which have revolutionized the entire science and art of medicine. To do anything like justice to these extraordinarily fertile and original researches of Pasteur is wholly out of the question here. I can merely direct your attention to the researches which in the fullest way exemplify Pasteur's gift of imagination and power of experimental control. There are six studies or groups of studies whose histories exhibit Pasteur's genius at its best—the research on the tartrates, the investigations on fermentation, the inquiry into the causes of the silkworm disease, and the methods of its eradication, the research on chicken cholera and immunity to it, the research on anthrax, with the extraordinarily dramatic scenes attending the public test of the immunization methods, and finally the masterly researches on hydrophobia. People have, in general, been perhaps most impressed by the researches on hydrophobia. Here Pasteur dealt intimately with a disease affecting man. The horrible effects of rabies on human personality, the publicity of the first daring attempts at prevention by the use of attenuated virus, the personal activity and earnestness of Pasteur in these human experiments, the circumstance that the rabic virus was an invisible foe of unknown nature—all these features combined to give to these studies a greater prominence than was accorded other Pasteurian

investigations of equal or perhaps even greater merit from the standpoint of originality and constructive intellect.

In all these different groups of researches were displayed the most active powers of associative thought and phantasy, the most admirable capacity for self-criticism. As Pasteur made his publications in a terse, compact style, we can not always reconstruct his logical processes by reading them. His methods of thought and procedure were, however, well known to his colleagues, with whom he loved to discuss his ideas and plans of experiments. They found him spirited, fertile and imaginative in his conceptions, frankly communicative, generous in giving help and wholly absorbed in his work. Like many intensely serious men, Pasteur lacked somewhat the sense of humor. His feelings of partisanship were so strong that he could never overcome his resentment toward Germany, and he permitted this to color even his relations with German scientific workers. Yet one should dwell but lightly on these slight imperfections in a nature of such great gifts and such lofty and unselfish purpose.

At the time when Pasteur was beginning his research on anthrax, a young student of medicine at the University of Strassburg, Paul Ehrlich, was laying the foundations for that uniquely fertile and versatile career of medical research which has made him the most original and picturesque of living investigators of medical science. Although at this time Ehrlich was especially under the direction of the anatomist, Waldeyer, he rapidly developed a capacity for chemistry which was a surprise both to himself and to the chemist, Adolf von Beyer, whose lectures had been systematically cut by the gifted but unconventional student. For unconventional he then was and ever has been, neglecting what he did not like and throwing himself with fervor and intense energy into the solution of the themes that attracted him. From the outset it was clear that Ehrlich would make a career as an experimental investigator. Much of the time he was supposed to spend in taking the usual medical courses he devoted to experiment. When Robert Koch was shown through the laboratory at Breslau by one of the professors his attention was called to a young student working at a desk covered with bottles of dyestuffs. "There is our little Ehrlich," said the professor; "he is a first-rate stainer of tissues, but he will never pass his examinations." The prediction about the examinations came perilously near fulfilment; Ehrlich made bad flunks and it is hinted that he would

never have received his degree had not he made a discovery—namely, the existence of the peculiar type of leucocyte which is known to us as the "plasma-cell." The faculty reasoned that it would be improper to keep so promising and original a worker indefinitely in an undergraduate position, and it is suspected that they mitigated the rigor of the examinations in order to relieve their own embarrassment.

A noteworthy example of Ehrlich's free-lance method is seen in his peculiar way of working at chemical problems. Though a highly accomplished organic chemist, both as to theory and a singularly rich acquaintance with the properties of substances, Ehrlich rarely uses any but the simplest methods and quite refuses to work quantitatively. His personal experiments are almost exclusively test-tube experiments, most ingeniously contrived to yield a rich fund of knowledge. He says:

> For the pure chemist, who proceeds analytically or synthetically, my way is only an unending *pons asinorum*. The chemist starts from two substances, *a* and *b*, both of which he knows, and by synthesis derives substance *c*. Through this procedure a sure insight into the nature of the process becomes possible. This is exactly as if one drew a circle with the calipers. On the other hand, one may define a circle by means of a large number of tangents, and the chemistry which I practise is a kind of tangent chemistry. Through my schooling in this tangent chemistry I have had a great advantage in dealing with immunity problems. If one cannot define chemically the components entering into action, as is frequently the case in immunity problems (for example toxin and antitoxin) one cannot draw the circle in the usual chemical way and the nature of the reaction process must remain a closed book. But for one who has worked for decades, as I have done, at tangent chemistry, the task is no longer so difficult; and I think that in this way, through the recognition of toxoids and their quantitative formation from toxins, I have succeeded in correctly bringing out the two functional groups, the toxophore and the haptophore, which indeed furnish us with the key to the entire doctrine of immunity.

Ehrlich's dominant interests during the student days were histology and chemistry, but his attitude toward these subjects was even then highly individual, original and laden with the dynamic spirit—the spirit that seeks to gain a conception of what goes on in the living cells. Throughout his career Ehrlich has sought to use his knowledge of histology and of chemistry to gain light on the process of life. The clarity of his visual perceptions and the tenacity of his visual memories have enabled him to cultivate a sort of chemistry peculiarly suited to this aim. Ehrlich early recognized that he had a peculiar gift of being able to recall and represent mentally the constitution of a large variety of substances and with little effort to picture vividly their interactions. He

definitely states that he considers this chemicoplastic memory his greatest scientific endowment, and it is clear that the long line of his investigations is founded on this faculty and on his taste for rational therapeutics. Like Helmholtz and Pasteur, Ehrlich has been guided in his experiments by certain well-defined general conceptions. The most important of these in Ehrlich's case is the idea that the living cells have many different kinds of definite chemical affinities, by virtue of which they are able to enter into combination with some compounds and not with others. This idea is at the foundation of Ehrlich's well-known researches on the basophilic, acidophilic and neutrophilic leucocytes, on the distribution of dyestuffs in the so-called "intravital" staining, on the cell affinities of the different alkaloids, on the side-chain theory of immunity and the measurement of the strength of antitoxin, and on the organic chemical compounds of arsenic in relation to the trypanosomes of the sleeping-sickness.

The recital of Ehrlich's achievements in medicine would demand a voluminous space, for his activities have been intense and varied. The pharmacological studies, the work on immunity in its different phases (including the action of hemolysins), the experimental studies on carcinoma—each of these deserves the most careful study, not merely because of actual results gleaned, but on account of the luminous ingenuity of the methods employed.

It is in the field of immunity that Ehrlich has won his brightest laurels. The discovery that vegetable poisons like abrin and ricin excite antitoxicity, the development of a method of measuring the activity of the diphtheria antitoxin—a standard method the world over—the extremely ingenious studies of hemolysins, the recognition of the laws of transmission of immunity from mother to child, and the discovery of immunity in trypanosomes exposed to the action of arsenical poisons, are all contributions of far-reaching import. And cementing all Ehrlich's special investigations of immunity, relating them also with his work on the distribution of dyestuffs, alkaloids and nutritive materials generally, stands the famous "side-chain" theory. This bold, elaborate and refined hypothesis of the nature of immunity, this offspring of rich phantasy and fertile experimentation, was long the source of discord and strife among bacteriologists and pharmacological theorists. At the height of the controversy Ehrlich once remarked: "They are shooting into my antitoxin tower and I will reply vigorously." To-day a

welcome peace—perhaps merely a truce—has succeeded the sometimes heated contest, and only an occasional stray shot is heard. However widely the rival camps may disagree on certain points, there seems now to be a common ground. The centrally emergent conception in immunity appears to be the existence of a specific binding or anchoring avidity between the immunity-excitant or antigen and certain substances belonging to the living cell—the so-called receptors. This conception and the extensions that follow from it—including, for example, the now familiar view that the antitoxin freed in the blood represents excessively multiplied receptors disengaged from the stimulated cells—are peculiarly original with Ehrlich. His mind reached this central idea, because it is a mind beset by chemical phantasy, a mind seeking to explain all biological phenomena in medicine by means of chemical principles. In the special case of the side-chain theory, Ehrlich's intimate knowledge of the chemical and biological properties of the dyestuffs played a very large part, and it should be noted that the theory is in this sense a hybrid, that it originates not from a purely chemical conception, but from a chemical and a biological idea. Slowly that theory grew to its present full proportions and its somewhat bewildering intricacies of superstructure. In this elaborate form there is doubtless much in the hypothesis that can be criticized if we turn to it in the hope of learning the absolute truth in respect to immunity. It is perhaps just to say that the value of the theory lies largely in the fact that it expresses relationships. Time and experiment will doubtless mold it anew. But whatever changes in form it may suffer, the data collected by Ehrlich and correlated by him will long remain a monument to his experimental genius and creative imagination. And the fair-minded critic will remember the great practical services which this theory has rendered and is still rendering to medicine, in enabling investigators to pursue their experiments in new territories of research in immunity by giving them points of attack and lines of advance. It is stated by Wassermann, the discoverer of the serum reaction of syphilis, that he could never have worked out this biological reaction had he not possessed the side-chain hypothesis as a guide. It seems clear, too, that the intelligent use of this hypothesis is destined to aid us greatly in learning something of the seat and mode of action of many drugs of which we now know but little. And, again, there are unmistakable signs that the side-chain conception will give many a clue to the understanding of the nutrition of cells.

Ehrlich's mind is singularly labile, playful and restless. It passes quickly and casually from one subject to another, yet without the least confusion. It is always on the alert, ready to dally with a new fact or a new idea, in the hope that it will illumine one of the many experimental interests with which consciousness ever teems. Ehrlich reads medical literature rapaciously but selectively, ignoring all but the themes in which he has a special interest, as one reads who reads for his pleasure and not for duty's sake. This unusual method is extremely effective and gives a highly serviceable command of facts likely to be helpful in extracting from Nature new facts by experiment. Even during holiday seasons, this spirituelle, penetrating mind knows no real rest, for the time is beguiled by the reading of detective stories, even second-rate ones, in the hope of finding some new and complicated situation, for which an ingenious solution can be invented.

It is a cheering sign of the times that the cultivated classes are beginning to recognize the essential rôle of imagination in the progress of the biological and medical sciences. President Eliot remarks that the nineteenth century has taught us that, on the whole, the scientific imagination is quite as productive for human service as the literary or poetic imagination.

> The imagination of Darwin or Pasteur, for example, is as high and productive a form of imagination as that of Dante, or Goethe, or even Shakespeare, if we regard the human uses which result from the exercise of imaginative powers and mean by human uses not merely meat and drink, clothes and shelter, but also the satisfaction of mental and spiritual needs.

The history of medical discovery is a long chain of imaginative experiences whose links have been welded and fixed by passing through the fiery ordeal of appeal to experimental tests. And could we but set forth, in fitting language, the true story of these mental experiences, with all their vicissitudes of hope and despair, success and failure, we should certainly dispel for all time the wide-spread notion that medical research is a dry and painful task, to which only an unimaginative mind can turn with satisfaction.

There is a phase of imaginative thought and feeling which expresses itself in a strong desire to pursue ideal ends, even at the cost of the ordinary prizes of life, wealth, material power and physical comfort. This idealism has been a very pronounced attribute of the great masters of medicine. In a noteworthy degree they have all possessed it and some, like Helmholtz and Pasteur, have led lives of unpretentious,

simple self-sacrifice in admirable harmony with the illustrious and superlative service they have rendered mankind. This idealism, while clearly a moral trait in the conventional sense, seems to be the offspring of the creative intellectual attitude and especially of an absorption in work, which leaves the mind neither time nor inclination to seek the petty advantages for which most men at some time in their lives find themselves struggling. For these reasons, indifference to vulgar aims and aloofness from commonplace interests are apt to be found where there is preoccupation in productive work of a high order, whether this be concerned with science or not. But in the medical sciences the rewards are so great, in the sense of personal satisfaction from superior achievement, that there is an especial and peculiarly potent incentive to repress those exaggerations of the self-preservative instinct which show so insistently in the selfish conduct of commonplace persons. Yet I do not think that it can be claimed that the motives of even the greatest masters of medicine have always been purely altruistic. In the days of struggle for recognition, during early manhood, there has commonly been evidence of mixed motives for action even in the case of the noblest men; and at this we can hardly wonder. Sometimes the spirit of self-interest has been given too free a rein. When Behring patented the diphtheria antitoxin, avowedly with the intention of gaining money for further research, he committed himself to a dubious policy and one that deprived many children of the benefits of the life-saving discovery by raising the cost of the antitoxin serum to a prohibitive level. When Morton found that sulphuric ether could be used for purposes of general anesthesia, he had no hesitancy in trying to secure for himself a patent for his method. When we contrast this attitude with that of Helmholtz, who gave the ophthalmoscope to medicine, and of Pasteur, who freely gave his immensely valuable discoveries, it is hardly necessary to comment on the difference in spirit that animated these men.

There is a special quality pertaining to the greatest masters of medicine which arrests our attention when we survey their life work. This is the wonderful variety and number of their discoveries. We are struck with this quality of productivity in the works of Hunter, Malpighi, Johannes Müller, Claude Bernard, Helmholtz, Pasteur, Koch and Ehrlich. In some instances the range of topics is relatively narrow, as in the case of Koch, or extraordinarily wide, as in the case of Helmholtz, but in nearly all instances the great masters have been repeatedly pro-

ductive, and this varied productivity on a high plane is an unfailing mark of genius. On the other hand, it is necessary to recognize that very important discoveries in medicine have been made by men who once in their lives, and once only, have attained a high level of achievement. There are two examples of this singularity in discovery which I would bring particularly to your notice—one the discovery and development of the antiseptic method by Lister and the discovery of general anesthesia by Morton.

When Lister visited Pasteur in 1865 he was much impressed by the attitude of the great master in regard to the wide part played by microorganisms in fermentation and disease. As a surgeon he had a deep interest in the diseases of wounds, and the idea established itself in his mind that such diseases might be due to a kind of fermentation which might be checked or prevented by the use of antiseptics. This idea, worked out by Lister with the utmost patience and superior intelligence, gave the wonderfully far-reaching results with which we are all familiar. The important results of Lister's methods are not limited to the surgical diseases of human beings. By making it possible to experiment on animals in wholly new ways, these methods have placed in the hands of the physiologist a powerful instrument for the extension of medical and biological knowledge along most significant lines of progress. We have, therefore, to concede that Lister's discovery is one of such rich fertility as to make it rank among the great discoveries of medicine. Yet it can not be claimed that Lister was a great scientist. In training, in originality, in versatility and in imagination he is far from being the peer of the great masters of whom we have spoken. And we see here, again, that the practical import of a discovery is no arbitrary measure of the scientific attainments of the discoverer.

Hardly less valuable an asset of practical medicine is the discovery of general anesthesia, but it appears that the qualities of mind revealed by Morton belong to a level less high than those of Lister. Morton was an alert, enterprising young dentist in Boston, who, while educating himself in medicine, successfully practised his calling and invented an improved system of dental plates. The use of this system required the free removal of carious and otherwise diseased teeth, and this caused great pain. To relieve this pain, Morton pertinaciously sought an efficient anesthetic. After many unsatisfactory trials with different substances, he experimented with sulphuric ether, given him by Jackson,

the professor of chemistry in the Harvard Medical School. In 1846 he succeeded in demonstrating the efficacy of sulphuric ether as a general anesthetic and thus gave to mankind a precious, almost unequaled boon.

This great discovery can not be reckoned as one of high fertility, since, aside from anesthesia, it has not opened new lines of thought or practical service. Neither can it be said to have sprung from a scientific mind of exalted qualities and attainments. It has the earmarks of a child of empiricism. Morton's scientific knowledge was slight and his mind had a strong commercial bent. The singularity of his discovery, the only one of his life, points neither to fertility of resource nor to lofty imagination, but rather to the fortunate combination of conditions under which he insistently exercised his ingenuity.

Having told you something of the qualities distinguishing the modern masters of medicine, I now ask your permission to speak of certain aspects of these qualities as they seem related to the career of the thoughtful student of medicine. And first of all I would correct in your minds any impression I may have made of a discouraging nature. Having drawn our examples of medical advance so largely from the work of supremely gifted men, workers in laboratories, many of whom have not been practitioners of medicine, or have only casually practised, it may possibly appear that you are confronted with the paradox that an essential condition of the loftiest success in medical science is to abstain from the practise of medicine. There is, indeed, a measure of truth in this, for, as I have already tried to show you, entire absorption in the practical problems of medicine unfits men to pursue with the highest success the career of discovery. In this there is naught of real discouragement, but only a sign that the problems of disease, as we meet them by the bedside, are far too complex to permit solution there. There was a time when all medical discovery was based directly on observation at the bedside. Then, with the growth of anatomy, the invention of the microscope and the coming of the twin handmaids of medicine, physics and chemistry, the laboratories sprang into existence. Much there was that could be discovered only by laboratory methods, and so it happened that some men were justified in working at medicine, and able to become masters of medicine, though they scarcely left their laboratories. But I would have you note well that we have now entered on a time when the clinics and the laboratories must work more and more closely together, aiding each other at every step to bridge the wide

chasms of our ignorance. And just here lies one of the greatest opportunities for the alert student of medicine, undergraduate and postgraduate, to do something worth while. For the problems are so many, so varied and so widely graded as to their difficulties that for almost every earnest student there is at hand a theme suited to his powers and training.

I have intimated my belief that the powerful and controlled imagination is generally associated with a strong vein of idealism. The explanation is not remote; the imagination separates the wheat from the chaff in the realm of ideals, picturing vividly what will yield enduring satisfaction. In persons of average capacity and imagination, idealism is more halting because the perceptions of what is permanently worth while are less definite and carry less firm conviction. Hence in such persons idealism of conduct is less spontaneous and calls for conscious effort to sustain it. It is, indeed, a quality which may be deliberately cultivated if the germ exists in the character.

What I would like particularly to impress on your minds is that without idealism of purpose, without the willingness to make sacrifices of material comfort and much that the world overprizes, the career of the student and practitioner of medicine is almost certain to be pitifully limited and mediocre. He will do well who has the character to run his course in a strong spirit of independence, satisfied during the long years of professional preparation with the slender means that permit the prolongation of some phase of the student life long after graduation from the medical school. There is no surer road to hopeless mediocrity than that which leads the young physician to assume an active practise before he is ripe for it. On the other hand, the student physician who waits patiently, year by year, to strengthen his intellectual grip on the processes of disease, if possible under the guidance of some master of medicine, is laying the unshakable foundations of a telling and distinguished career. He need have no anxiety as to the future either on the score of professional recognition or the ability to earn a sufficient income. For the world needs and must ever seek the serious, well-trained, idealistic physician whose first thought is to render a high grade of service. The superior type of student will not dread the long years of preparation in laboratory and clinic. He will eagerly seek them and will count it the greatest privilege of his life to be able to utilize and develop his powers. The fascinating interest of his problem and the

elevation of his ideals will keep him buoyant under circumstances of discouragement. If he be blest with a fair share of imagination and idealism he will never falter in the struggle to make a worthy career, for he will know that he is treading in the footsteps of the great masters of medical science and that in doing so he is helping to assuage human suffering, perhaps also to illuminate some of the dark problems in the baffling mystery of life. And in this consciousness will he find ample compensation for the self-abnegation which such a career must necessarily exact from its votaries.

THE MEDICAL SCHOOL OF THE FUTURE[1]

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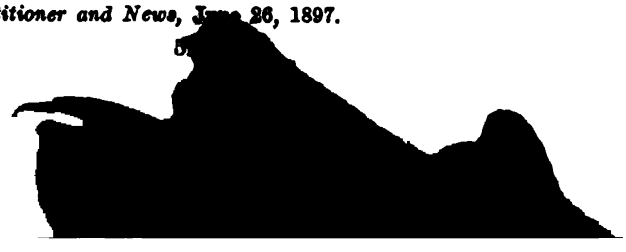
AMONG the intellectual movements that have characterized the century now drawing to a close, there is perhaps no one more deserving of careful study than that which is concerned with providing education for the people in the school, the academy and the university. The importance of popular education became apparent in proportion as political freedom was secured for the people. Thus Viscount Sherbrooke, better known as the Hon. Robert Lowe, in the reform debates of 1866 and 1867, after the passage of a bill for the extension of the suffrage, uttered the well-known words: "We must now at least educate our masters." The same sentiment has also more recently been embodied in the inscription on the Boston Public Library, "The Commonwealth requires the education of the people as the safeguard of order and liberty," and in the Presidential Address of Dr. J. M. Bodine[2] at the meeting of the Association of American Colleges in 1897, we find the same idea thus expressed: "In America the citizen is king. The king must be educated to wield aright his ballot sceptre."

For many years educators looked upon their work with no little complacency. The educational systems of the various civilized countries were supposed to be well adapted to the ends in view, and educational exhibits have generally been regarded as important features of international expositions. But within the memory of most of those now before me, signs of serious discontent have not been wanting. Education has not always been found to furnish the required safeguards for order and liberty. Highly educated men have often been found singularly lacking in mental balance. Schools for the inculcation of "common sense" have never yet been established. Even the great development of psychology as an experimental science, which has occurred chiefly within the last twenty-five years, though it has served to establish many laws

[1] Published in the *Transactions of the Congress of American Physicians and Surgeons*, 1900.

[2] *American Practitioner and News*, June 26, 1897.



of mental action, has thus far failed to justify the hope that pedagogy may find in psychology a foundation for the erection of rational systems of education. Indeed, we have recently been told by one of the ablest expounders of this science, that it is a great mistake for teachers to "think that psychology, being the science of the mind's laws, is something for which they can deduce definite programs and schemes and methods for immediate school-room use. Psychology is a science and teaching is an art. A science only lays down lines within which the rules of the art must fall, laws which the follower of the art must not transgress; but what particular thing he shall positively do within those lines is left exclusively to his own genius."[1]

Even this general guidance has been very imperfectly afforded, for the limits set by the science of psychology to the art of teaching have never been precisely defined. In fact, the most fundamental question of all, namely, the relation of mental to physical development, has not yet been settled, though much material for its study has been collected. It is not, therefore, surprising that in many countries teachers have made too great demands upon the time and strength of growing children.

This has been clearly the case in some parts of Germany, where school boys from eight to fifteen years of age have found their vital energy so far exhausted by the school work required of them that they have lost all inclination for vigorous athletic amusements so naturally indulged in by Anglo-Saxon boys. The deterioration of the race as a result of too close application to intellectual pursuits, to the neglect of the physique, has been fortunately obviated, in the case of Germany, by the army system, which takes entire possession of the youth before it is too late, and, by requiring him to devote three years to the education of his body, turns him out, at the end of that period, a young man with mind and body trained to a high degree of efficiency, well fitted for civil as well as military pursuits, and comparing favorably in all respects with men of his age in other nations. Looked at from this point of view, the German army must be regarded as an important part of the educational system of the country, though as a piece of educational machinery its workings can not be considered economical. In fact, the absurdity of depending upon the army to remedy the defects of the school system has long since been forced upon the attention of German educators, and the difficulties above alluded to are now in a fair way to be removed.

[1] W. James, "Talks to Teachers," p. 7.

In our own country difficulties of a quite different kind have been met with. Here the great danger which threatens our system of popular education arises from its close association with party politics. The office of a school committeeman in one of our large cities has been well described as "the smallest coin in which politicians pay their debts," and as long as the education of our children continues to be entrusted largely to men who consider their position on a school board as the lowest step of the political ladder, there is small hope of the adoption of rational methods of education. Moreover, this intimate alliance between education and politics greatly aids the efforts of persons, more zealous than discreet, to direct the instruction of children in accordance with their own special views. Thus nearly all the states of the union have upon their statute books laws requiring the physiological action of alcohol to be taught to children in all grades of the public schools. These laws violate the first principles of pedagogy, inasmuch as the physiological action of a drug can not possibly be understood without a familiarity with anatomy, physiology and chemistry which school children can not be supposed to possess. They have been passed at the bidding of total abstinence associations, sometimes in opposition to the earnest protests of the teachers entrusted with their execution. How these excrescences upon our educational system may be best removed, and the work of instruction placed under the control of those best qualified to direct it, are questions demanding serious consideration.

I have mentioned these instances in which great educational systems have been found wanting merely for the sake of pointing out that the critics of our methods of medical education, who, as Professor Exner[4] has shown, are now raising their voices in every land, do but give a special expression to a widespread feeling that our educational systems are not accomplishing all the objects for which they have been devised, and that the discontent which they imply is but a healthy dissatisfaction with the results thus far accomplished. May the time be far distant when those in charge of our educational interests shall rest content with what they have achieved, for this will indicate that a state of stagnation has been reached similar to that which characterizes the institutions of the celestial empire, and that no further attempt is to be made to adapt our methods of instruction to the constantly widening domain of human knowledge and experience.

[4] *Wiener klinische Wochenschrift*, 1900, No. 3.

It may perhaps be well for me at this point to offer a few words in explanation of the selection of such a well-worn theme as medical education as the subject of my remarks this evening. It is true that in recent years the subject has been a favorite one with those who have been called upon to address medical associations or classes of graduating students, and if, in spite of this fact, I venture to add another address to the fast-growing literature of the subject, my justification may be found in the following reasons. In the first place, it must be borne in mind that such addresses are very quickly forgotten. "Were it not so," as Dr. Billings has remarked, "it would be a hard world for address-givers." In the second place, the progress of medicine at the present time is so rapid that new points of view are constantly being secured, and it is, therefore, not at all impossible that, even at comparatively short intervals, new and valuable suggestions may be made, with regard both to subjects to be taught and to methods to be employed in giving the instruction.

Lastly, it so happens that during the academic year now nearly completed the faculty of the Harvard Medical School has inaugurated an entirely new plan of instruction in the sciences of anatomy, physiology and pathology. This scheme, though still in the experimental stage, embodies ideas of such fundamental importance in medical education that its presentation to a representative body of the medical profession seems to me to be peculiarly appropriate.

I shall therefore ask you to consider with me this evening what lessons the faculty of a modern medical school may draw from recent advances in medical science and recent experience in medical education, or, in other words, on what lines the instruction of a medical school of the first rank is likely, in the immediate future, to be organized. I say in the *immediate* future, for what changes are in store for us in the course of the next few decades it is equally impossible to foresee and useless to speculate.

Relation of Medical Schools to Universities

One of the most hopeful signs of the times in the field of medical education is the growing tendency of the better schools to ally themselves to universities, and of universities to establish medical departments. Of the great advantages to medical education which may be expected from this union it is unnecessary for me to speak, for they

formed the subject of a thoughtful discourse delivered by the last president of this congress at Yale University in 1888.[5] The twelve years that have elapsed since he spoke have brought accumulating evidence of the soundness of his views. In fact, it is difficult to see how a private medical school of the joint stock company type can ever, in the future, rise to the first rank, for such a school is not much more likely to attract endowments than a cotton mill and without endowments the enormous expenses of a modern first-class medical school can not possibly be met.

Great as are the benefits to a medical school of thus forming a department of a great university, the advantages of the union are not wholly on one side. Beside the increase of prestige secured to the university by the broadening of its functions, the establishment of a medical school as part of the university organization greatly facilitates the instruction of those students who, without any intention of becoming physicians, seek in the study of the medical sciences a means of general culture and mental discipline.

The relations between the governing body of a university and its medical faculty in matters of administration are often defined by custom and tradition rather than by statutory provisions, and vary considerably in different institutions. In general, two methods of government may be distinguished. Either the initiative is left with the teaching faculty, the governing body exercising simply a veto power, or the governing body acts directly without necessarily asking advice from the faculty or its members. The former method of government is most likely to be found in those cases in which a well-established medical school has allied itself to a university for the sake of the mutual benefits that may ensue from the union, and the latter method in those cases in which a university has completed its organization by the creation of a medical department. Both methods have certain advantages and neither is without its drawbacks. In all cases men are more important than methods. On the one hand, the collective judgment of a teaching faculty on matters relating to medical education is likely to be of more value than that of a governing body which may not, and generally does not, include physicians among its members. On the other hand, personal and selfish considerations are perhaps more apt to sway the judgment of a faculty than that of a body of trustees, especially when the question is that of the appointment of teachers. That this is not a serious danger, how-

[5] *New Englander and Yale Review*, September, 1888.

ever, the experience of Germany seems clearly to show, for in that country, as Dr. Farlow has recently pointed out, the faculty "has more power in regard to appointments and the general policy of the university"[6] than with us, and yet we find there the custom of calling professors from one university to another fully established—a custom which must be regarded as one of the strongest influences in maintaining a high standard of educational efficiency. On the whole, therefore, even with this possibility of error, the judgment of a faculty would seem to be the safer guide, and there are probably few boards of trustees who would feel themselves justified in disregarding it altogether.

The above-mentioned advantages of a union between a medical school and a university will naturally become more obvious as the problems of medical education become more complex and the methods of instruction more costly. Hence we may expect in the near future to find all of the better class of medical schools under the ægis of a university and we may reasonably hope that this change will be associated with a diminution of the total number of medical schools now so greatly in excess of the needs of the country.

The union of a medical school with a university at once compels the consideration of the proper relation between the academic department and the professional school. To say that the former should be the feeder of the latter and that the holding of an A.B. degree should be the condition of admission to professional studies is to adopt the position taken by two of our leading medical schools.

The A.B. degree, however, since the introduction of the elective system, no longer stands for a definite amount and kind of training. Hence the Johns Hopkins Medical School demands not only the diploma, but also evidence of ability to read French and German and laboratory training in physics, chemistry and biology. The Harvard Medical School is content to accept the A.B. diploma as evidence of fitness to pursue professional studies, stipulating only that the holder shall possess an adequate knowledge of inorganic chemistry. Whether the example set by these schools will be generally followed is quite doubtful. Without undervaluing the importance of collegiate training as a preparation for a professional career, it may perhaps be contended that a properly conducted admission examination is a better test of fitness to

[6] Presidential address, American Society of Naturalists, December, 1899, *Science*, January 5, 1900.

pursue the study of medicine than the possession of a diploma the value of which varies so much with the character of the college bestowing it. Moreover the possibility that a young man unable to afford the expense of a college course may yet by private study prepare himself for a professional career is not to be lost sight of. Hence the Harvard school provides for the admission by a special vote of the faculty of young men, not holders of an A.B. degree, who may furnish satisfactory evidence that they have obtained an equivalent education and that they are consequently able to profit by the instruction which the school has to offer.

The recent lengthening of the course of study from three years to four in all the best medical schools of the country has drawn renewed attention to the importance of enabling the student who takes the A.B. degree as a preparation for medicine to so far shorten the sum total of the time devoted to his education that he may be able to enter upon the work of his profession at an age not in excess of that at which his European *confrères* begin their career as practitioners. A few years ago an examination of the best accessible evidence on the subject led to the conclusion that foreign systems of university education enabled students of medicine to enter upon their life work at least two years earlier than was possible for the alumni of Harvard College, a condition dependent upon the fact that the changes in the academic department which had raised the age of graduation had been made with little regard to the interests of the professional schools and chiefly for the purpose of making the undergraduate department as complete as possible in itself. In other universities a similar condition existed, though probably not to the same degree as in Harvard.

That the American medical student, seeking the best possible preparation for his profession, is seriously handicapped by these conditions, has been generally recognized, and the question of the best method of meeting the difficulty has been widely discussed. The most thorough treatment of the case consists in reducing the academic course to three years. Less radical methods are the provision in the academic department of courses of instruction by which students may anticipate a part of their professional work and the permission to count the first year of a professional course as the fourth year for the bachelor's degree. The first and most radical method meets with strenuous opposition owing to the deeply rooted traditions which surround the four years' academic course in this country, while the other plans violate what in some col-

leges seems to be regarded as an educational axiom, that one course of study should not count toward two degrees. It is interesting to notice that, without any specific legislation to this end, the quiet working of the elective system has in Harvard College practically solved the problem by bringing about a condition in which, as President Eliot says,[7] "Any young man of fair abilities can now procure the degree in three years without hurry or overwork, if he wishes to do so or his parents wish to have him." The President further ventures to predict that "within a time comparatively short the majority of those who enter the freshman class will come to college with the purpose of completing the requirements for the degree in three years." As soon as a three years' residence becomes the rule rather than the exception, a young man spending four years in college will of course be regarded either as deficient in mental capacity or as having wasted his time.

That a reduction of the academic course to three years is an advantage to students looking forward to a professional career or to further study in a graduate school, is too obvious to need discussion, but it is interesting to find the change advocated in the interest of the undergraduates themselves. Professor Clement L. Smith, for nine years dean of Harvard College, points out[8] that there is a large and influential class of college men who get into the habit of frittering away their time simply because they have so much of it and that "for them and for those whom they influence—and these men make up the largest part of the class we are now considering, the men who go from college into active life—the reduction of the course would be a distinct gain." Nor need we fear (as has sometimes been urged) that, in thus reducing the length of the college course, we shall lose the fourth and most valuable year, for, as Professor Smith says, "The senior year is the best year, not because it is the fourth, but because it is the last year. The causes which make it what it is come from before, not from behind; from the consciousness of opportunity passing away and of the serious problems of life close at hand. The period of waste lies between the fresh zeal and good resolutions with which the youth begins his course and the growing sense of responsibility with which he draws near its close. It is this intermediate period that would be shortened in the brief course. It is

[7] Annual Reports of the President and Treasurer of Harvard College, 1898–99, p. 10.

[8] Clement L. Smith, "The American College in the Twentieth Century," *Atlantic Monthly*, February, 1900.

not the senior year that would be cut off; it is rather, let us say, the sophomore year, and with it might well go its absurd name." It thus appears that the claims of the college and of the professional school upon the time of the student are in a fair way to be harmoniously adjusted.

The Elective System

Let us now consider in what way the medical school of the immediate future is likely to differ from that of the present time with regard to the subject-matter of instruction. The most striking phenomenon presenting itself to the educator of to-day is the recent enormous widening of the educational horizon. "The immense deepening and widening of human knowledge in the nineteenth century and the increasing sense of the sanctity of the individual's gifts and will power"[9] are the fundamental facts which underlie the development of the elective system, but it is important to bear in mind that, as Professor Smith observes,[10] this development has been "due not so much to the increase of knowledge—for not all new knowledge is straightway fit for educational purposes—but rather to the conversion of new fields of knowledge to the uses of education."

A discussion of the elective system of education with its attendant advantages and dangers would require far more time than I have at my disposal, and I must content myself with pointing out the possibility that, in this period of transition, the educational pendulum may have swung to an extreme position and that too much attention has been given to the accidental differences of pupils, while the essential similarity of their natures has been lost sight of. In discussions on individuality as a basis for the elective system one sometimes hears the statement (attributed to Leibnitz) that no two leaves of the same tree are alike. This dissimilarity, however, does not prevent them from all elaborating the same sap, and it is, moreover, always associated with sufficient essential similarity to enable any one, with even the most elementary knowledge of trees, to distinguish the leaves of an oak from those of a maple.

While admitting that some of the extreme positions now maintained by the advocates of the elective system may in the future have to be abandoned, no one can doubt the wisdom of adapting the education to the powers of the mind to be educated and of allowing, in the case of

[9] C. W. Eliot, *Atlantic Monthly*, October, 1899, p. 443.
[10] C. L. Smith, *Atlantic Monthly*, February, 1900, p. 219.

advanced students, the choice of the individual to be a determining factor in the selection of studies. Let us, therefore, inquire to what extent the elective system may properly find a place in the curriculum of our medical schools. That it forms an essential feature of our post-graduate schools of medicine scarcely needs to be mentioned, for these schools have been organized for the express purpose of enabling graduates in medicine to select such subjects for study as may seem to them desirable and to acquire more advanced knowledge than was possible in the undergraduate course. Moreover, in some of our larger schools, since the establishment of the compulsory four years' course, a portion of the instruction of the fourth year has been given in elective courses in various specialties. The elective system in medicine is, therefore, not altogether a novelty, and the question now before us is whether it may be profitably extended to the earlier years of the course.

In his remarks at the dinner of the Harvard Medical Alumni Association in 1895, President Eliot used the following language: "There ought to be in the Harvard Medical School an extended instruction far beyond the limits of any one student's capacity. This involves, of course, some optional or elective system within the school itself, whereby the individual student should take what is, for him, the best four years' worth, the faculty supplying teaching which it might take a single student eight, twelve or twenty years to pursue."[11]

One year ago last December, in an address which I had the honor to deliver in New York before the American Society of Naturalists,[12] I gave the reasons which seemed to me conclusive in favor of this extension of the elective system, and, with your permission, I will take the liberty of presenting as briefly as possible the views there set forth.

In the first place, it may be assumed that a medical school of the first rank should be an institution in which the most advanced instruction in all departments of medicine can be obtained, and on this assumption it is, of course, impossible to arrange a course of study that every student must follow in all its details, for, in the time which may properly be devoted to a course of professional study, it is quite impossible for even the most intelligent students to assimilate all the varied information which such a school may be reasonably expected to impart.

It seems, therefore, to be evident that in arranging a course of med-

[11] *Bulletin Harvard Medical Alumni Association*, No. 8, p. 40.

[12] See *Science*, N. S., Vol. VIII., No. 209, p. 921, and *Boston Medical and Surgical Journal*, December 29, 1898.

ical study a distinction must be made between those subjects which it is *essential* that *every* student should know and those subjects which it is *desirable* that *certain* students should know, that is, between those things of which no man who calls himself a physician can afford to be ignorant and those which are important for certain physicians but not for all; in other words, provision must be made both for required and for elective studies. The task of drawing the line between the essential and the desirable in medical education will require the greatest possible good judgment and readiness for mutual concession on the part of those engaged in the work, but there is no reason to fear that the difficulties will be found insuperable when the importance of the change has once been recognized.

Any one who is familiar with the existing methods of medical instruction is aware that in nearly every department many things are taught which are subsequently found to be of use to only a fraction of those receiving the instruction. Thus, the surgical anatomy of hernia is taught to men who will subsequently devote themselves to dermatology, future obstetricians are required to master the details of physiological optics, and the microscopical anatomy of muscles forms a part of the instruction of men destined to a career as alienists. Now no one can doubt the propriety of including instruction on all these subjects in the curriculum of a medical school, but it may be fairly questioned whether every student should be forced to take instruction in them all.

To better indicate the nature of the reform which I am advocating, allow me to describe a possible arrangement of a course of study in the department of physiology, with which I am of course more familiar than with any other. An experienced lecturer will probably find it possible to condense into a course of about forty or fifty lectures all the most important facts of physiology with which every educated physician must necessarily be familiar. Attendance upon these lectures, combined with suitable courses of text-book instruction and laboratory work, would suffice to guard against gross ignorance of physiological principles. In addition to this work, all of which should be required, short courses, of not more than eight or ten lectures each, should be provided, giving advanced instruction in such subjects as the physiology of the special senses, cerebral localization, nerve-muscle physiology, the internal secretion of glands, the physiology of the heart, circulation and respiration, the digestive secretions, the reproductive organs, etc.

These courses should be elective in the sense that no student should be required to take them all. Each student might, however, very properly be required to choose a certain number of courses, which when once chosen become, for the student choosing them, required courses leading to examinations. There is, in my opinion, no doubt that an arrangement of instruction similar to that here suggested for physiology could be advantageously adopted in the departments of anatomy, histology, bacteriology, medical chemistry, pathology, surgery, and in the courses of instruction in the various special diseases, such as dermatology, ophthalmology, etc.

In the existing state of medical education the introduction of the elective system in some form or other seems to be an essential condition to any further important advance, for the curriculum of most of our schools is already so crowded that no considerable amount of instruction can possibly be added. Various arguments may, of course, be advanced in opposition to the change. It may perhaps be urged that no choice of studies can be made without determining to some extent the direction in which the work of a future practitioner is to be specialized, and that such specialization can not be properly and safely permitted until the student has completed his medical studies. To this it may be answered that, whatever may be the dangers of too early specialization, the dangers of crowding the medical course with instruction of which many students do not feel the need, and of thus encouraging perfunctory and superficial work, are certainly no less serious. It is, moreover, a matter of common observation among teachers in medical schools that a certain number of students very early make up their minds either that they will become surgeons, obstetricians, or specialists of some sort, or, on the other hand, that they have a strong aversion to certain branches of medicine and a determination never to practise them. For such students a prescribed curriculum necessarily involves great loss of time and energy.

If it be said that under this system the medical degree will cease to have the definite meaning now attached to it, and that it will be impossible to tell from his diploma in what way a physician has been educated, it may be replied that, though the degrees of A.B., A.M., Ph.D. and S.D. are affected with exactly this same uncertainty of signification, their value seems in no way diminished thereby. As long as the M.D. degree stands for a definite amount of serious work on med-

ical subjects, we may be reasonably sure that those who hold it will be safe custodians of the health of the community in which they practise.

If it be urged that the elective system in medical education will lead to the production of a class of physicians who, owing to the early specialization of their work, will be inclined to overrate the importance of their specialty and to see in every disease an opportunity for the display of their special skill, it may be pointed out that this result is apt to be due not so much to early as to imperfect instruction in the work of a specialist, and that since the elective system tends to encourage thoroughness in special instruction, the evil may be expected to diminish rather than to increase.

Methods of Instruction

Having thus recognized the necessity of remodeling our conception of the subject-matter to be taught, and noted the importance of distinguishing between the essential and the desirable in medical education, we must next consider by what methods the needed information may be best imparted and the necessary training secured. There is perhaps no way in which modern educational methods differ more from those of an earlier period than in the greater prominence given to object lessons. Beginning with the kindergarten, the child is trained to cultivate his power to observe accurately and to manipulate skilfully, and through his school and college life prominence is given to the objective side of education to an extent which would have seemed to the book-trained pedagogues of a former generation but ill adapted to provide the well-stored mind which it was thought to be the principal object of education to secure. In the professional schools also the reaction against purely didactic methods has been strongly felt. Even in those professional pursuits to which the object method might seem at first sight least applicable, in the study of the law, the so-called "case method" of instruction has been found to exert a vivifying influence.

In medical education in this country it is interesting to note that in the very beginning the instruction was more objective in its character than at a somewhat later period. In those early days it was in the office of his preceptor and at the bedside, as his actual assistant, that the embryo physician was initiated into the mysteries of his calling. Then followed a period when it was clearly perceived that the trained mind is necessary to interpret the data of observation, and that

mental training is essential to correct observing. Hence schools were established to provide this training by means of systematic didactic lectures covering all the departments of medicine and usually extending over not more than four months. These schools were intended at first merely to supplement the work of the preceptors, but in process of time the relative importance of these two educational agencies was reversed and the work of the preceptors became supplementary to that of the schools. The function of the preceptors finally became so subordinate that their names no longer appeared in the catalogues, though this did not always indicate that they had ceased to afford students opportunities for practical clinical work.[18]

The schools, once established, grew chiefly by an increase in the length and number of the lecture courses as new and important subjects forced themselves upon the attention of the medical profession. Against this undue extension of purely didactic methods of instruction a reaction has now set in, and during the last ten or fifteen years loud voices have been raised in advocacy of more objective methods than those at present in use. It is not, however, the reinstatement of the preceptor that is urged, but rather the greater use of laboratory methods in the strictly scientific departments of medical instruction and their application as far as possible at the bedside of the patient. A fruitful discussion of the relative advantages of the laboratory, the lecture and the text-book as methods of medical education can not be undertaken without a recognition of the fact that this education has a double object. In the first place, the faculties of the student are to be so trained that he may observe carefully, reason correctly, study effectively and judge wisely; in other words, he is to be "trained for power," to use President Eliot's phrase. In the second place, there must be imparted to him a sufficiently large fraction of the acquired medical knowledge of the time to make him a safe custodian of the health of the community. Which of these two objects is the more important is a question which we need not now discuss, but even if we grant all that is claimed by the advocates of training for power, it is evident that the constantly increasing range of subjects with regard to which an educated physician must be informed will greatly reduce the time which, in the curriculum of a medical school, may properly be devoted to courses of instruction not intended to impart direct and valuable information. In fact,

[18] Henry Hun, *Albany Medical Annals*, October, 1896.

"training for power" should be largely a function of the academic department of a university, and when undertaken in a professional school should be so directed as to impart at the same time the greatest possible amount of useful information.

Let us now consider how far the didactic and the laboratory methods of instruction are each adapted to secure these two objects of medical education. For the purpose of training for power no one can doubt the value of the laboratory method. Contact with the phenomena themselves and not with descriptions of them has a stimulating effect upon the mind of a student, the importance of which it is difficult to exaggerate, but it does not follow from this that the lecture, the recitation and the text-book are worthless as methods of training. It is here that some of the advocates of laboratory methods have committed what appears to me a serious error, such as is too apt to characterize all reform movements, the error, namely, of assuming that, because one proposition is true, another proposition, not logically inconsistent with it, must be untrue. "These gentlemen," as Professor Howell[14] has expressed it, "having become possessed of the golden truth that the best knowledge is that which comes from personal experience, seem disposed to deny all value to knowledge communicated from the experience of others." We are told, for instance, by Dr. Burr[15] that the didactic lecture "dates from the time when printing was unknown and manuscripts were rare and almost priceless and the only means of communicating knowledge was by word of mouth. To-day it is in large part an anachronism, because the time devoted to it could be put to better uses."

In his able address[16] at the Yale University Medical Commencement, my colleague, Dr. C. S. Minot, expressed himself as follows: "The very best that can be said of a lecture or a book is that it describes well the knowledge which some one possesses. There is no knowledge in books. . . . A book or a lecture can serve only to assist a man to acquire knowledge with lessened loss of time. Knowledge lives in the laboratory; when it is dead we bury it decently in a book. . . . A lecture is a spoken book." I venture to believe that Professor Minot's students will hardly agree with this estimate of the lifeless character of either his written or his spoken instruction.

[14] Howell, *The Michigan Alumnus*, January, 1900, Vol. VI., p. 143.
[15] *Philadelphia Medical Journal*, October 21, 1899.
[16] Minot, *Science*, July 7, 1899.

In place of these rather disparaging views of the importance of a didactic lecture, I am inclined to accept Dr. Weir Mitchell's[17] opinion that "The best lecturing does not so much think for you as invite you to think along suggested lines of inquiry." If, as has been claimed, "the passive attitude of listening does not demand of the students intelligent thought,"[18] the fault must lie with the lecturer and not with the method of instruction. In every department of medicine advanced instruction necessarily deals with subjects which lie within what Foster has called the "penumbra" of solid scientific acquisition and about which conflicting views are therefore certain to be held It is in inviting thought with regard to the evidence on which these views rest that the experienced lecturer has his best opportunity to train the minds of his hearers. Other opportunities are also afforded by the historical presentation of subjects about which differences of opinion no longer exist, for there are few things more instructive than to follow up step by step the lines by which our knowledge has advanced, noting the marks which distinguish the paths which have been trodden successfully from those which have turned out to be "no thoroughfare." Even better opportunities for mental training than those which the lecture-room presents are afforded by the recitation, for here the minds of the teacher and the pupil are brought most closely into contact, the pupil's difficulties are appreciated by the instructor and the point of view of the teacher can be learned by the pupil. It has always seemed to me that no higher enjoyment falls to the lot of the teacher than that which he experiences when, by a series of carefully considered questions, he leads his pupil onward from the known to the unknown and notes the gleam of intelligence which illumines his countenance as a subject, previously obscure, becomes clear, as a result of his own mental operations guided by his teacher's skillful questions. It thus appears that no monopoly of opportunities for mental training can be claimed for the laboratory method of instruction.

We must next inquire, what are the relative advantages of the laboratory and didactic methods as means of imparting information? Here we at once perceive that a great deal will depend upon the kind of information to be imparted. Certain subjects are much better adapted than others to be taught in the laboratory. The student of anatomy,

[17] *University Bulletin*, Vol. III., p. 85, Philadelphia, December, 1898.

[18] W. B. Cannon, A.M., "The Case Method of Teaching Systematic Medicine," *Boston Medical and Surgical Journal*, January 11, 1900.

for instance, can secure the greater part of the information which he needs by laboratory methods, that is, in the dissecting room, though a short course of lectures in descriptive anatomy in which an experienced teacher emphasizes the salient features of the subject will probably always be indispensable. Physiology and pathology (including physiological chemistry, pharmacology and bacteriology) are subjects in which laboratory instruction may be unquestionably much more freely used than is customary at the present time. The recent experience of the Harvard Medical School, in which the laboratory courses in these subjects have been greatly extended, has furnished conclusive evidence of the value of this method of instruction as a means both of imparting information and of stimulating the mind of the student. It must be remembered, however, that, as Dr. Welch[19] has said, "laboratory methods are extremely time-taking and are not adapted to teach the whole contents of any of the medical sciences. It is, of course, hopeless to attempt to demonstrate practically all of even the more important facts that the student should learn."

Moreover, observed facts are often apparently inconsistent with each other. Equally competent observers differ in their interpretation of them. Yet, because the last word of science has not been spoken on these subjects, it would be a mistake to exclude them from the medical curriculum. The student should rather be carefully instructed as to researches which have not yet yielded definite results. The most probable way of reconciling conflicting observations should be pointed out, and he should be shown in what direction the search for truth can be prosecuted with the best prospect of success. He will then be able to appreciate the value of new observations and to assign to their true position the reported discoveries in medical science.

Instruction of this sort can, of course, be given only by an experienced lecturer who has mastered the subject of which he treats. It is in this kind of teaching and in the exposition of those facts and principles which can not properly be made the subject of laboratory instruction to students, that the didactic lecture of the future will probably find its principal field of usefulness. In the latter direction, however, the field is more restricted than might at first sight appear, for the amount of practical work that can be successfully performed by first

[19] "Higher Medical Education and the Need of its Endowment," *The Medical News*, July 28, 1894.

and second year students in a physiological or in a pathological laboratory is surprisingly large. In the physiological department of the Harvard Medical School, for instance, during the current academic year, each pair of students in a class of one hundred and eighty has been furnished with a kymographion, a capillary electrometer, a moist chamber, an induction coil, unpolarizable electrodes, etc., and the most important experiments of nerve-muscle physiology have been successfully repeated. The fundamental experiments in the physiology of the circulation, respiration, etc., are to be performed in a similar manner. In the pathological laboratory the students, working in sections of ten, have had an opportunity of producing for themselves and studying experimentally the most important pathological degenerations. They have also studied in the same way the principal infectious diseases. In the anatomical department also, while the number of didactic lectures has been diminished, the whole class has had largely increased facilities for the practical study of bones and of various special organs.

Still, after making due allowance for the legitimate expansion of laboratory teaching, it is probably safe to say that a systematic course of lectures in each of the medical sciences will never be found to be superfluous, and that the day is probably far distant when the lectures will be merely "explanatory of the experiments."[20]

We have thus far considered the relative advantages of didactic and laboratory methods in teaching the medical sciences, but the agitation in favor of more objective teaching has extended also to the clinical departments of medicine and the organization of "clinical laboratories," in which the cases of hospital patients may be studied by the most refined methods of physiological and pathological research, is a natural outcome of this agitation. In fact, however, so far as instruction is actually given at the bedside, clinical medicine has always been taught by means of object lessons. In many of our schools this instruction has been supplemented by so-called "conferences," exercises in which a student reports before the class a case which he has himself examined, giving diagnosis, prognosis and treatment. The subject is then discussed by the class and finally by the instructors.

Wherever actual cases of disease are thus utilized for teaching purposes the instruction is always likely to be more or less haphazard and unsystematic, for the diseases studied will be those of which actual

[20] Porter, *Boston Medical and Surgical Journal*, December 29, 1898.

cases happen to be available. To remedy this difficulty it has been recently proposed[21] to substitute the study of hospital records of cases for the examination of the cases themselves, a method quite analogous to that known as the "case method," which has long been used with great success in training students in the Harvard Law School. It will thus be possible to group cases so that they will throw light upon each other and, though the student will miss the stimulus of contact with the actual patient, the method presents so many distinct advantages that it will doubtless commend itself to many teachers of clinical medicine and of theory and practise.

It is thus evident that the reaction against purely didactic methods of instruction is well under way. It is a movement to be heartily welcomed, for there can be no doubt that medical students have been, and still are, too much lectured, but, like all other reforms, it should be carefully guided lest useful as well as useless things be swept away. It should be borne in mind that it is quite as easy to abuse the laboratory as the didactic method of instruction and that in all schemes of education a good teacher with a bad method is more effective than a bad teacher with a good method. As Professor Howell[22] has well remarked, "Courses of lectures that if analyzed would be found to be top-heavy and lop-sided and otherwise possessed of an instability that should have ensured failure, have been saved and made instruments of great value by the mere earnestness of the teacher."

Distribution of Work

The next question which I shall ask you to consider is that of the proper distribution of the work of a medical student. Thirty years ago no such question seems to have presented itself to the minds of instructors in medicine. The medical faculties of that time contented themselves with providing each year courses of lectures covering all the departments of medicine, as they were then understood, and every student was expected to attend as many of the lectures as he saw fit. Between 1870 and 1880 the fact that there is a natural sequence in medical studies became generally recognized and graded courses of instruction were established in the principal medical schools of the country. The grading was not, however, carried sufficiently far. Thus,

[21] W. B. Cannon, A.M., *loc. cit.*

[22] Howell, *loc. cit.*, p. 144.

instruction in both anatomy and physiology was generally given simultaneously through the whole of the first year, though the knowledge of structure should logically *precede* a study of function.

The time seems now to have come for taking another step in grading medical instruction, and during the academic year now drawing to a close instruction in the Harvard Medical School has been given in accordance with a plan of which the guiding principles are concentration of work and sequence of subjects. Thus in the first half of the first year the students devote themselves exclusively to the study of anatomy, including histology and embryology. In the second half-year they are occupied with physiology, including physiological chemistry, while in the first half of the second year pathology, including bacteriology, engages their attention. It is perhaps too early to pass a final judgment upon the value of the method, but thus far both teachers and students seem to regard it as a success. The result seems to have justified the opinion of its advocates that the work of the student would be made "easier by concentrating his thoughts upon one subject instead of dissipating his attention upon many subjects."[23] Nor have its opponents found any justification for their fears that the average brain would become fatigued and unreceptive by too close application to one subject, for the sciences of anatomy, physiology and pathology "are not narrow, hedged-in areas, but rather broad and diversified domains composed of many contiguous fields,"[24] in passing from one to another of which the student may rest his mind without interrupting the continuity of effort essential to effective work.

An obvious objection to this method of concentrating instruction is the large amount of work which it imposes upon the instructors. There is no doubt that the labor of teaching every day in the week may task the powers of even the most enthusiastic instructor, but it has been found that the laboratory work, which has occupied from two to three hours every forenoon, has been conducted with much less fatigue than was anticipated. In fact, students, when supplied with printed directions for work and with the necessary apparatus, need remarkably little supervision. In the physiological laboratory it was found that one instructor could readily supervise the work of fifteen pairs of students, and the experience in the anatomical and pathological departments was of a similar sort.

[23] Minot, *loc. cit.* Reprint, p. 22.
[24] Porter, *loc. cit.* Reprint, p. 12.

Examinations

Closely connected with the questions of method of instruction and of distribution of work is the subject of examinations. With regard to these tests of our educational methods, opinions vary even more widely than with regard to the methods themselves. There is only one point, as Professor Exner has remarked, on which teachers are practically united, and that is "that an examination is a necessary evil." Every examiner knows only too well that an examination is but a very imperfect test of knowledge, but few are ready with any suggestion of a substitute. Much of the confusion which prevails in the discussion of this subject would be removed if the objects to be secured by an examination were more clearly apprehended. Professor Exner[35] points out that examinations may be broadly divided into two classes, namely, the *Controlprüfung,* to test the faithfulness with which the student has performed his daily tasks, and the *Reifeprüfung,* to determine the amount of his permanently acquired knowledge of medical subjects.

The examination which, at the end of the year, covers the whole ground of the twelve months' instruction, and which is so common in our schools, belongs to neither of these two classes and is really a concession to a very natural wish of the students to get the examination "out of the way" while the subject is still fresh in their minds. Having little justification from an educational point of view, we may hope to see it abandoned when the extension of laboratory methods provides in the note-book and graphic records of each student the evidence of his daily work and thus either renders a further examination unnecessary or prepares the way for a final test of his fitness to receive his diploma of M.D. Whether the written or the oral examination affords the better method of applying this test is a question about which opinions vary. The fact that some persons can write more readily than they can talk, while others can talk more readily than they can write, seems to be a reason for providing a mixed method of examination in which each individual may have an opportunity of appearing to the best advantage.

Conclusions

If the views here presented are well founded, we may expect that a medical school of the first rank will in the immediate future be organized and administered somewhat as follows:

[35] Exner, *loc. cit.* Reprint, p. 3.

1. It will be connected with a university, but will be so far independent of university control that the faculty will practically decide all questions relating to methods of instruction and the *personnel* of the teaching body.

2. It will offer advanced instruction in every department of medicine and will therefore necessarily adopt an elective system of some sort, since the amount of instruction provided will be far more than any one student can follow.

3. The laboratory method of instruction will be greatly extended and students will be trained to get their knowledge, as far as possible, by the direct study of nature, but the didactic lecture, though reduced in importance, will not be displaced from its position as an educational agency.

4. The work of the students will probably be so arranged that their attention will be concentrated upon one principal subject at a time and these subjects will follow each other in a natural order.

5. Examinations will be so conducted as to afford a test both of the faithfulness with which a student performs his daily work and of his permanent acquisition of medical knowledge fitting him to practise his profession.

If I have clothed these conclusions in the language of prophecy, it is because the title of my discourse has laid this necessity upon me. In forecasting the immediate future, I have borne in mind the history of the immediate past, and if I have failed to read aright the indications of the lines on which our medical schools are to advance, it must be remembered that the development of a biological science and of its dependent arts not infrequently takes place in totally unexpected directions, thus introducing into the path of educational progress perturbations which may well defy prediction.

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